TELEVISION
TO-DAY & TO-MORROW

SYDNEY A. MOSELEY
AND
H. J. BARTON CHAPPLE

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Elgin.

TELEVISION

TO-DAY AND TO-MORROW

FROM THE SAME PUBLISHERS

PHOTOELECTRIC CELLS

THEIR PROPERTIES, USE, AND APPLICATIONS

By Dr. N. R. CAMPBELL and DOROTHY RITCHIE

Members of the Research Staff of the General Electric Company, Ltd., Wembley

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A practical book explaining the theory, use, and application of the Photoelectric Cell, and written so that it will be of value to all users and all who are interested in these cells, from the professional physicist to the wireless amateur.

PART I

THEORY OF PHOTOELECTRIC CELLS

A GENERAL SURVEY—THE PHOTOELECTRIC EFFECT—PHOTOELECTRIC EMISSION—PHOTOELECTRIC DATA—THE ELECTRIC DISCHARGE — THE VOLTAGE-CURRENT CHARACTERISTIC—INTERMITTENT CURRENTS—THE CHOICE OF A PHOTOELECTRIC CELL.

PART II

USE OF PHOTOELECTRIC CELLS

SOME GENERAL PRINCIPLES—ELECTROSTATIC METHODS—VALVE AMPLIFICATION—SPECIAL METHODS.

PART III

APPLICATIONS OF PHOTOELECTRIC CELLS

LUMINOUS FLUX—ILLUMINATION—COLOUR—ABSORPTION—INDEX

Mr. John Logie Baird

Frontispiece

TELEVISION

TO-DAY AND TO-MORROW

BY

SYDNEY A. MOSELEY

AND

H. J. BARTON CHAPPLE

WH.SCH., B.Sc.(HONS.), A.C.G.I., D.I.C., A.M.I.E.E.

SIEMENS MEMORIAL MEDALLIST AND PREMIUM, HENRICI MEDALLIST

WITH A FOREWORD

BY

JOHN L. BAIRD

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TO FRIENDS AT
THE B.B.C.
WHO MADE THE FIGHT FOR
TELEVISION
SO INTERESTING

FOREWORD

The past three years have seen enormous developments in television, but I think many must have been bitterly disappointed at the long delay in placing receiving apparatus in the hands of the public.

In 1926 television was demonstrated for the first time, and there seemed little reason why the apparatus should not come into public use without undue delay. Three years have passed, however, and only now are television receivers becoming generally available. One of the reasons for this delay was that in the original television apparatus synchronizing was by means of synchronous motors, and automatic synchronism had to be brought into being before a television set suitable for the home could be provided. The chief cause of delay in bringing television to the public was, however, the difficulty experienced in obtaining facilities for broadcasting.

The general public are of the impression that television was first broadcast through the B.B.C. only a few months ago, and it will be a surprise to many to learn that this is not the case, but that the first broadcasts of television through 2LO actually took place as far back as 1926. In July of that year we applied to the B.B.C. to be permitted to send out television from Motograph House, which was then the headquarters of the company, and this permission was granted to us, on the condition that we should not use it for propaganda purposes. Several transmissions took place through 2LO, and were received by us. These transmissions were, however, brought to an abrupt conclusion by the Post Office authorities, and we

resolved to send out our own television programmes. We applied for a licence and obtained the licence 2TV, authorizing us to transmit television on a power of 250 watts and a wavelength of 200 metres. Our experience through the B.B.C., however, short as it was, had been sufficient to show definitely that the waveband of 2LO was amply sufficient to send out television images. There was, in fact, no difference whatsoever between the images received through 2LO and the images we were receiving by land line. That was in 1926.

Having definitely witnessed television sent out successfully through 2LO, although not permitted to mention this, I was amused at times by the dogmatic assertions of various " authorities," who, by making elaborate calculations based on the entirely erroneous assumption that television was transmitted by dots, " proved " to their own complete satisfaction that television on a waveband of 10 kilocycles was utterly impossible.

Unfortunately, a breach arose between ourselves and the B.B.C., and we continued to develop entirely independently. The struggle to obtain broadcasting facilities is described in the first chapters of this book, and I will say nothing more about it here.

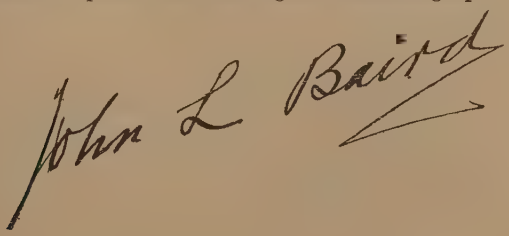
The present images are restricted to simple scenes, such as head-and-shoulder views, or a few people seated close together. This limitation is imposed upon us by the narrow waveband available, but we are making experiments on the short wavelengths, which provide a much larger available waveband without causing interference.

To what extent pictures may be improved within the limitation of 10 kilocycles is a matter upon which it would be a mistake to dogmatize—for example, it must not be taken for granted that television is bound by the

same laws which govern cinematography. There is no necessity to send as many as 22 pictures per second. We send only 12½ at present, and if we use a screen upon which is impressed a permanent or semi-permanent image, the recording point being preceded by an obliterating point, that is to say, that on each traversal of the screen the previous image is obliterated by a point immediately preceding the recording point, then the limit of picture speed is fixed by the rapidity of movement of the person or scene being televised, and not by any question of flicker.

I may say that in the laboratory we have transmitted pictures at as slow a speed as three per second, and these pictures have been visible as a united whole. At that speed, however, rapid motion is impossible, and a man who turns his head rapidly gives the impression of having left his nose behind, or a hand moved up and down looks as if the fingers were made of sealing wax. As I say, however, the speed of picture transmission in television is not bound by the laws of cinematography, and those who endeavour to fix limitations to the progress of television, basing their arguments upon established arts, may fall into as grave errors as those who based their calculations upon half-tone blocks, and assumed the television image to be made up of dots.

I have indicated one line of future development, and would like to conclude by saying that I see no insurmountable barrier in the way of the advancement of television to a perfection rivalling the cinematograph.



Mr. Baird was the first to effect practical television and to inaugurate a new departure in electric technics which will have immense developments in present and future years.

SIR JOHN AMBROSE FLEMING.

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INTRODUCTION

To prophesy is a dangerous venture, but it seems customary to commence volumes of this sort with some nightmare prophecy—a plumber's vision of a world filled with weird mechanism, with thought-reading machines, with all sorts and conditions of apparatus for propelling the body from one end of the earth to another, enabling us to see what goes on in Mars and planets, and moving us with the velocity of light for week-end trips to Uranus.

As fantastical as all these things may appear, one has only to look back even for a hundred years and consider the stupendous advancement of knowledge and accretion of powers which have been acquired by the human race—we cannot, it is true, project our bodies through space to the Antipodes, but we can and do project our voices, and we can and have projected our images, so that we can be seen and heard over these vast distances, although, as yet, we cannot be felt. With the further step whereby the transmission of touch can be added to the transmission of sight and sound, we might be seen, heard, and felt over any distances.

What then remains? Our personalities are only cognizable to our fellows by the senses, so that if we can transmit the sensations of sound, vision, and smell, we have to all intents and purposes solved the problem of transmitting our bodies corporeally over space.

In jest it has been suggested that the time will come when we shall be able to read each other's thoughts by the aid of some diabolical mechanism.

This dream is by no means so weird or so impossible

of realization as it might at first sight appear, for all thought is, in analysis, only an electrical disturbance of our nerves.

Impulses pass along our nerves as a series of electrical telegraph signals, and our thought itself is nothing more or less than a conglomeration of these impulses.

Our brain has been compared to a stupendous telephone exchange.

We have the incoming signals—messages from the outer world—they are received in the brain, sorted out by the operator whom we term our consciousness, and this operator sends out corresponding messages, telling the various organs of the body what they must do in answer to the incoming messages which he has received. The operator is in many cases entirely dismissed, when the incoming signals themselves operate the corresponding outgoing signals. We put our foot in the fire, and without any conscious effort it is withdrawn. The whole body is, indeed, but a complex combination of physical and electrical reflexes, and there are many who consider that consciousness itself does not exist, but is a mere phenomenon of this complex combination of reflexes which constitutes our mentality.

We have at our disposal the most amazingly delicate apparatus for detecting electrical disturbances of all kinds, and this apparatus in the laboratories of physicists has already enabled the nervous impulses to be detected, so it is no strange thing for the physicist to hear the sounds caused by the rushing of pain impulses through the nervous system. He can apply his headphones to his ear and hear pain send its signal along the nerve to the brain.

Very well, then. Is it not legitimate to imagine that with a developed apparatus in time to come we may hear not only pain impulses, but the impulses of love,

of hate, of desire, rushing headlong through that complex nerve structure to the brain, and that hearing these impulses we may learn that a certain definite conglomeration of sound caused by the nervous impulses corresponds to hate, that another combination of sounds caused by another set of impulses in the brain corresponds to love, and further still shall recollect that all thought in the brain of the thinker is cognized in terms of words?

We think, and as we think we speak, but our speech is not audible. Our thought may, indeed, be augmented by imagery. We may think both in images and words, but the great bulk of mankind, and mankind's clearest thinkers, think almost entirely in words.

Sometimes we may hear a man think walking along a desolate or deserted road. Many a deep thinker thinks audibly, but in company and generally these thought impulses which we have heard audibly are inhibited. He forms his thoughts into words, but these words are never given breath to. Nevertheless, although not audibly uttered, they have existed as nerve impulses, and these nerve impulses might, with a properly constructed and sufficiently delicate apparatus, be turned into a conglomeration of sounds—of sounds, it is true, bearing no definite resemblance to the speech which they represent, but which would correspond to it and could, with the necessary knowledge, be interpreted.

There, then, we have a theory and practical facts upon which the constructon of a thought-reading machine may be visualized.

What, then, of the future with its thought-reading machines, with its space-destroying machines, and even, perhaps — who knows? — its time-destroying machines!

Such visions may intrigue the mechanically-minded, but to others they bring neither inspiration nor hope, but only that terrible question: "To what end?"

* * * *

To many wireless experts some of the points included here may appear elementary, but I am providing for the reader whose knowledge of the technical side of television is limited.

I ought to add that I started out to write a piquant history of television as I knew it at first hand, but the subject has grown out of hand.

I found history was being made even as I wrote.

On the top of this came the publication of certain books on television written by Americans and published by English houses who were not, apparently, aware of the incomplete nature of their knowledge of the subject.

It was also very evident from these works that only the American side of television was stressed, and an altogether insufficient tribute was given to the man who had done more for television than any of his contemporaries. It is only meet, therefore, that we should balance matters by telling the story of the progress of Baird television, and give in the simplest language possible an explanation of "how the thing is done."

The scope of this work has also been extended so as to include the very latest developments in regard to noctovision, phonovision, and tele-cinema. With the desire of making it as complete and as up to date as possible, I have called in the aid of a young technical journalist, Mr. Barton Chapple, who has been one of the foremost among writers on the subject.

I am also deeply indebted to Mr. Baird, who has glanced through the proofs, and to the Chief Engineer of the Baird Company, Commander Jacomb, who has

been intimately associated with Mr. Baird in his work. Commander Jacomb read through the technical chapters of the work, and has offered many interesting suggestions.

I am indebted to Captain Hutchinson, Managing Director, and to the Secretary of the Baird Company, Mr. T. W. Bartlett, for the use of an excellent series of photographs, many of which were specially taken, and which will help the reader considerably in his study of the subject.

I have dedicated the book to my friends of the B.B.C., since no book purporting to tell the story of television would be complete without mention of the bright and interesting chapter of history in this connection.

SYDNEY A. MOSELEY

Press Club,
London, 1930.

The Latest Form of Baird Televisor

TELEVISION
TO-DAY AND TO-MORROW

CHAPTER I

HISTORY OF TELEVISION

TELEVISION as an idea dates back over half a century, when Bell's invention of the telephone, in 1876, created a stir in the scientific world.

This event was followed almost immediately by the publication of numerous theories for the transmission of sight by electricity. These theories, strangely enough, were, in the main, identical in conception with the most important principles on which television to-day operates.

Early Theorists

It is one thing, however, to postulate a theory, and quite another to produce an actual working mechanism. Bell's telephone had been anticipated in theory, so were Edison's phonograph and Marconi's wireless experiments, yet many years had to elapse before the theory of television reached practical accomplishment. The man who succeeded in that vital step was Mr. John Logie Baird, upon whose work this book is founded.

To go back again to the early theorists, the outstanding name of Nipkow must be mentioned. It is his spiral disc which forms a prominent part in the present-day television apparatus. Weiller's name must not be forgotten, as he was the originator of the mirror drum, which forms the basis of certain apparatus now emerging from the experimental stage; but although

these theorists were early in the field with a description of their apparatus, nearly thirty years elapsed before television was actually achieved.

A public demonstration of the transmission of outlines was given at Selfridge's in April, 1925, when Mr. Baird, with the crudest of apparatus, transmitted by wireless the outlines of simple objects

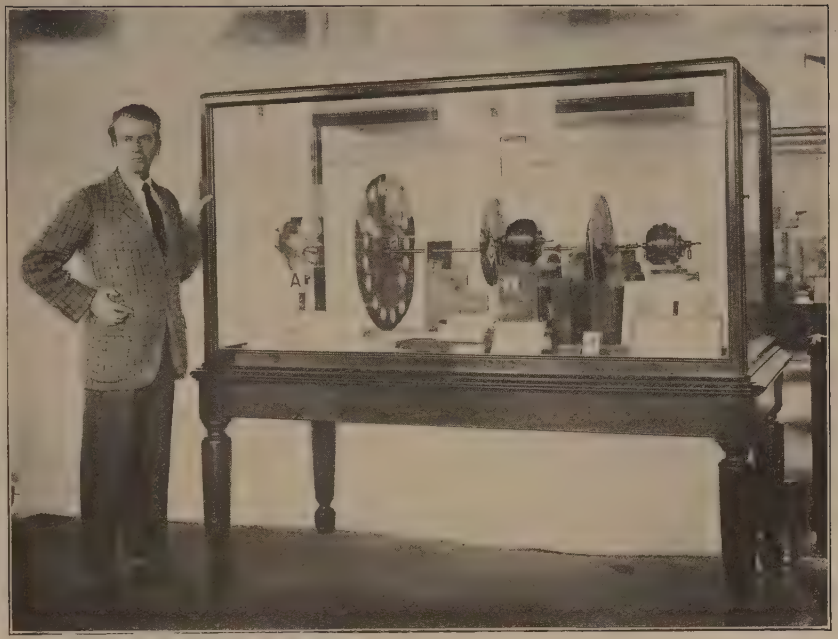
First Demonstration of Television

In addition, silhouettes were transmitted in America by Mr. C. F. Jenkins in July, 1925, but it was not until January, 1926, that true television was accomplished, and the gigantic step made from the transmission of silhouettes to the transmission of real images.

On 27th January, 1926, Mr. Baird gave a demonstration to some forty members of the Royal Institution, and showed them the transmission of real images between one room and another by television—the living human face being transmitted. Since it is our claim that this was the first time in history that actual television had been demonstrated, it is useful to quote the account of the demonstration given in *The Times* of 28th January, 1926—

Members of the Royal Institution and other visitors to a laboratory in an upper room in Frith Street, Soho, on Tuesday saw a demonstration of apparatus invented by Mr. J. L. Baird. . . .

For the purpose of the demonstration the head of a ventriloquist's doll was manipulated as the image to be transmitted, though the human face was also reproduced. First on a receiver in the same room as the transmitter, and then on a portable receiver in another room, the visitors were shown recognizable reception of the movements of the dummy head and of a person speaking. The image as transmitted was faint and often blurred, but substantiated a claim that through the " Televisor," as Mr. Baird has named his apparatus, it is possible to transmit and reproduce instantly the details of movement, and such things as the play of expression on the face.



Mr. J. L. Baird with his Original Television Apparatus, which is now in the South Kensington Museum, London

Praise from Independent Critics

Demonstrations were also given to representatives of the technical and scientific press, and since rival claimants are making their tardy appearance, an account which appeared in *Nature* of 3rd July, 1926, written by Dr. Russell, F.R.S., the Principal of Faraday House, is worth quoting—

> We saw the transmission by television of living human faces, the proper gradation of light and shade, and all movements of the head, of the lips and mouth, and of a cigarette, and its smoke were faithfully portrayed on a screen in the theatre, the transmitter being in a room at the top of the building. Naturally, the results are far from perfect. The image cannot be compared with that produced by a good kinematograph film. The likeness, however, was unmistakable, and all the motions are reproduced with absolute fidelity. This is the first time we have seen real television, and, so far as we know, Mr. Baird is the first to have accomplished this marvellous feat.

Evidence from the United States, where the growth of interest in television is manifest, may be seen in the *Radio News* (America's foremost radio journal) of September, 1926, which sent a special commissioner to investigate Mr. Baird's claim—

> Mr. Baird has definitely and indisputably given a demonstration of real television. It is the first time in history that this has been done in any part of the world.

Similarity to Present-day Apparatus

In recalling these past events, it is of great importance to note that the apparatus used by Mr. Baird in these experiments is almost identical with that now in common use. The receiving apparatus consisted of the same disc, with a spiral arrangement of holes (the Nipkow disc). Behind this was the same neon tube, and a synchronous motor was used to obtain synchronism.

The device is described in *Nature* as follows—

A series of demonstrations was given by Mr. J. L. Baird, of an experimental apparatus of his own design for wireless "television" (i.e. the simultaneous reproduction at a distance of an image of a fixed or moving object). The inventor does not claim any great perfection for his results, but we have seen the production in the receiver of a recognizable, if rather blurred, image of simple forms, such as letters painted in white on a black card, held up before the transmitter. Mr. Baird has overcome many practical difficulties, but we are afraid that there are many more to be surmounted before ideal television is accomplished.

In the transmitting apparatus, the object, strongly illuminated, is placed opposite a revolving disc provided with a series of lenses, each a little nearer to the centre than the last, which project a series of moving images upon a selenium or other photo-electric cell, each a little displaced laterally from the last. This is the equivalent of passing the cell over the whole surface of the object in a succession of close parallel lines. The light thus reaching the photo-electric cell is rhythmically interrupted by a rapidly revolving slotted disc, and the result is that owing to the variations of resistance of the cell, undulations at an audio-frequency are produced in the current through it, whenever a bright part of the object is being dealt with. These are amplified and supplied to a simple wireless transmitter, which is caused to emit corresponding signals.

In the receiving section of Mr. Baird's television apparatus, the signals sent out from the transmitter are detected and amplified by very powerful valves, until they are strong enough to light up a neon tube when a signal is received, i.e. when a bright part of the object is being dealt with by the transmitting apparatus. A disc, with lenses or holes corresponding to the lenses of the transmitting disc, is rotated synchronously with the transmitting disc, causing spots of light produced by the neon tube to appear upon a screen in positions corresponding to the part of the object being dealt with. With a sufficiently rapid rotation of the discs, a recognizable image of the subject is produced. A duplicate of the receiving apparatus is provided at the sending end with its disc mounted on the same shaft as the transmitting disc, to enable the necessary adjustments to be made. Synchronism between the sending and receiving discs is obtained by a little alternator with a frequency of about 300 geared to the revolving system, which causes signals to be sent out by another

At the Leeds British Association Meeting in 1927 Sir Oliver Lodge was Successfully "Noctovized"

wireless transmitter at this frequency. These are received and amplified at the receiving station to an extent enabling a similar little alternator connected to the receiving discs to be synchronized with them.

(Extract from *Nature*, 4th April, 1925.)

The First Model

It is of interest to the reader to know that Mr. Baird's original apparatus, with which he gave the first demonstration of silhouette television at Selfridge's, is now in the South Kensington Museum, London, and the following is an extract from the description attached to the model by the Museum authorities—

ORIGINAL TELEVISION APPARATUS
MADE BY J. L. BAIRD, ESQ.
Lent by Messrs. Television, Ltd.

This is the transmitting portion of the original apparatus used by Mr. J. L. Baird in experiments which led him from the wireless transmission of outlines in 1925 to the achievement of true television nine months later, when, **on 27th January, 1926, the transmission of living human faces with light, shade, and detail was demonstrated before members of the Royal Institution, this being the first demonstration of true television ever given.**

Baird's priority was clearly recognized in the U.S.A. The *New York Times* of 6th March, 1927, gave a whole page to the subject, and referred to the fact that—

No one but this Scottish Minister's son has ever transmitted and received a recognizable image with its gradation of light and shade.

The Vision of Objects in Total Darkness

The next noteworthy step in the progress of television took place on 30th December, 1926, when Mr. Baird

demonstrated the vision of objects in total darkness, by applying the *infra*-red rays to television. Here is an eye-witness's account—

It may be of interest if I give a brief résumé of the demonstrations Mr. Baird has given to me at Motograph House. Last June he gave a demonstration of the transmission of the images of living people, showing gradations of light, shade, and detail. An account of this demonstration was published in *Nature* of 3rd July, 1926.

The images, naturally, were not comparable with those shown on a modern cinema screen, but the likenesses were unmistakable. The person whose image was transmitted sat in a flood of brilliant light. Mr. Baird has now developed a method by which the image of the person is transmitted, although he is in complete darkness. This result is obtained by flooding the "sending" room by *infra*-red rays. On the 23rd November, 1926, Mr. Baird gave a demonstration to Mr. W. R. Crookes and me. One of us stayed in the sending room with a laboratory assistant in apparently complete darkness. In the receiving room, on another floor, the image of the assistant's head was shown brilliantly illuminated on a screen, and all the motions he made could be readily followed.

These images were not outlines or shadowgraphs, but real images by diffusely reflected rays. The application of these rays to television enables us to see what is going on in a room which is apparently in complete darkness. So far as I know, this achievement has never been done before.

We had the impression that the image on the screen was not quite so clearly defined as when visible rays were used, but we easily recognized the figures we saw, and made out their action. The direct application of Mr. Baird's invention in warfare to locating objects apparently in the dark seems highly probable, but I hope that useful peace applications will soon be found for it.

ALEXANDER RUSSELL.

FARADAY HOUSE,
SOUTHAMPTON ROW, W.C.1.
28th January.

(Extract from *Nature*, 5th February, 1927.)

DAILY MAIL COPYRIGHT
Television from London to Glasgow. Professor Taylor Jones, Sir John Samuel, Sir John Henderson and other prominent Glasgow citizens watching the reception.

Successfully Receiving the Television Transmission by Land Line from London to Glasgow

The First Television Demonstration Outside Britain

In April, 1927, the American Telephone and Telegraph Co. staged a most elaborate demonstration of television, the first to be given outside England. At this demonstration images were sent between New York and Washington, and the experiment was staged with the greatest publicity and the utmost elaboration, occupying in all the services of 1,000 engineers. The remarks of Dr. Dauvillier, an independent French scientist, writing in the *Revue Générale de L'Electricité* (7th January, 1928) upon this achievement, need no further comment.

ÉTUDE DES DIVERS PROCÉDÉS PROJETÉS OU RÉALISÉS

By M. A. Dauvillier

Para. 26. Procédé de la Bell Telephone Company. Enfin, la Bell Telephone Company a récemment réussi à transmettre à grande distance, sans fil, le visage humain en utilisant (sans le dire!) le procédé Baird.

Translation

SURVEY OF THE DIFFERENT SYSTEMS, SUGGESTED OR CARRIED OUT

By M. A. Dauvillier

Para. 26. "The Bell Telephone Company's System." Finally, the Bell Telephone Company recently succeeded in transmitting to a considerable distance, by wireless, the human face, using (without saying so!) the Baird system.

Using Service Telephone Lines

The American Telephone and Telegraph Co.'s demonstration was followed by Baird's transmitting images between London and Glasgow, over the ordinary service telephone lines. Baird accomplished this with the aid

of only two operators, his receiver consisting of a simple apparatus placed in the sitting-room of the Central Station Hotel, Glasgow. On this apparatus Baird and others were seen and recognized by leading scientists and city men of Glasgow. Professor Taylor Jones, who holds the Chair of Physics at Glasgow University, described the demonstration in the following words—

On the 24th and 26th May I proceeded, at the invitation of Mr. John L. Baird, to the Central Station Hotel, Glasgow, to witness demonstrations of television between London and this city. I was received by Mr. Baird's colleague, Captain Hutchinson, who explained that the transmission was to take place over the telephone line, Mr. Baird, in his laboratory in London, being in charge of the transmitting apparatus.

The earlier apparatus devised and used by Mr. Baird has been described by him in the *Journal of Scientific Instruments* for February, 1927. A model of the original transmitting apparatus is in the possession of the University of Glasgow, of which Mr. Baird was a former student. The following additional information as to the method has been supplied by him—

The method used in the London-to-Glasgow demonstration consisted in passing an image of the object being transmitted over a light-sensitive cell in a series of strips. The modulated current from the cell was transmitted over the ordinary trunk telephone line, and at the receiving station in Glasgow was used, after amplification, to control the light of a glow discharge lamp, a modified form of neon tube, giving a light of intense brilliance, being employed. By means of a revolving slotted shutter a point of light from this lamp was caused to travel over the field of vision in exact synchronism with the traversal of the image over the cell at the transmitting station, complete traversal taking place in about one-eighth of a second.

The receiving apparatus was set up in a semi-darkened room, the lamp and shutter being enclosed in a case provided with an aperture. The observer looking into the aperture saw at first a vertical band of light in which the luminosity appeared to travel rapidly sideways, disappearing at one side and then reappearing at the other. When any object having "contrast" was placed in the light at the sending end, the band broke up into light and dark portions forming a number of "images" of the object. The impression of sideway movement of the light was then almost entirely lost, and the whole of the

THE SCENE ON THE LINER "BERENGARIA" ON THE HISTORIC OCCASION WHEN TELEVISION IMAGES TRANSMITTED FROM LONDON WERE SEEN IN MID-ATLANTIC

image appeared to be formed simultaneously. The image was perfectly steady in position, was remarkably free from distortion, and showed no signs of the " streakiness " which was, I believe, in evidence in the earlier experiments. The size of the image was small, not more than about 2 in. across when the " object " was a person's face, and it could be seen by only a few people at a time. The image was sufficiently bright to be seen vividly even when the electric light in the room was switched on, and I understand that there is no difficulty in enlarging the image to full size. I was told also that arrangements will soon be made for transmitting larger " objects," and for increasing the number of appearances of the image per second.

The amount of light and shade shown in the image was amply sufficient to secure recognizability of the person being " televised," and movement of the face or features was clearly seen. At the second demonstration some of those present had the experience of seeing the image of Mr. Baird transmitted from London while conversing with him (over a separate line) by 'phone.

My impression after witnessing these demonstrations is that the chief difficulties connected with television have been overcome by Mr. Baird, and that the improvements still to be effected are mainly matters of detail. We shall doubtless all join in wishing Mr. Baird every success in his future experiments.

(Extract from *Nature*, 18th June, 1927.)

Baird Startles the World with Epoch-making Experiment

On 9th February, 1928, the public were startled to learn that the Atlantic had been spanned by vision. Using a short wave station, situated at Coulsdon, Baird had succeeded in transmitting images to Hartsdale, a suburb of New York. Note the remarks of the *New York Times* of 11th February, 1928, in regard to this demonstration—

Baird was the first to achieve television at all, over any distance. Now he must be credited with having been the first to disembody the human form optically and electrically, flash it piecemeal at incredible speed across the ocean, and then reassemble it for American eyes.

His success deserves to rank with Marconi's sending of the letter " s " across the Atlantic—the first intelligible signal ever transmitted from shore to shore in the development of transoceanic radio telegraphy. As a communication, Marconi's " s " was negligible; as a milestone in the onward sweep of radio, of epochal importance. And so it is with Baird's first successful effort in transatlantic television.

Reception in Mid-ocean

The transmission across the Atlantic was followed almost immediately by the transmission to the " Berengaria " in mid-ocean, where the chief wireless operator of this ship was enabled to see his fiancée in Long Acre, London. In an interview with a representative of the *Television Magazine*, Mr. Brown, chief wireless operator of the " Berengaria," said—

It was a wonderful experience to be able to see Miss Selvey like that in mid-Atlantic, and the achievement clearly demonstrates the enormous progress which has been made in television.

The First Daylight Television

In June, 1928, television by daylight was accomplished in the Baird laboratories, and it is pleasing to note Sir Ambrose Fleming's remarks on this achievement, as published in the *Television Magazine* for July, 1928—

The writer has had the opportunity of seeing in practical operation in Mr. Baird's laboratory a very striking advance in the apparatus for television which has been recently made by Mr. Baird.

In this vast improvement it is not necessary for the face or object, the image of which is to be transmitted for television, or " televised " (if one may venture to coin such a word), to be scanned by a brilliant beam of light traversing it, or to be flooded by powerful infra-red rays as explained below. The object whose image is to be transmitted can be simply placed in diffused daylight, just as if the ordinary photograph of it had to be taken. The transmitting apparatus is then placed near to the object, and the image of it appears on the screen

Mr. Jack Buchanan Posing before the Daylight Television Transmitter in July, 1928

at a distance when proper synchronism is secured. The advantage of this important advance will be clear. It means that the face of a singer or speaker can be transmitted by television at the same time that the voice is being picked up by a microphone for ordinary wireless broadcasting. It means a great step forward in the possibility of transmitting to a distance the image of moving objects or persons as seen in ordinary daylight, without exposing them to rapidly moving beams of light, or to dazzling illuminations or dark heat radiation.

The television transmitter becomes, in fact, a more complicated kind of camera, in which the screen on which the image appears is not immediately behind the lens, but may be miles or hundreds of miles away.

Television in Natural Colours

In August, 1928, Mr. Baird demonstrated television in natural colours, and the report of this achievement is proof of the interest it created—

We have seen Baird's method of producing colour television. The process consists in first exploring the object, the image of which is to be transmitted, with a spot of red light, next with a spot of green light, and, finally, with a spot of blue light. At the receiving station a similar process is employed, red, blue, and green images being presented in rapid succession to the eye.

The mechanism used at the transmitter consists of a disc perforated with three successive spiral curves of holes. The holes in the first spiral are covered with red filters, in the second with green filters, and in the third with blue. Light is projected through these holes, and an image of the moving holes is projected on to the object. The disc revolves at ten revolutions per second, and so thirty complete images are transmitted every second—ten blue, ten red, and ten green.

At the receiving station a similar disc revolves synchronously with the transmitting disc, and behind this disc in line with the eye of the observer are two glow discharge lamps. One of these lamps is a neon tube, and the other a tube containing mercury vapour and helium. By means of a commutator, the mercury vapour and helium tube is placed in circuit for two-thirds of a revolution and the neon tube for the remaining third. The red light from the neon tube is accentuated by placing red filters over the view holes for the red image. Similarly, the view holes corresponding to the blue

and green images are covered by suitable filters. The blue and green lights both come from the mercury helium tube, which emits rays rich in both colours.

The colour images we saw which were obtained in this way were quite vivid. Delphiniums and carnations appeared in their natural colours, and a basket of strawberries showed the red fruit very clearly.

(*Nature*, 18th August, 1928.)

Stereoscopic Television

After Mr. Baird had successfully demonstrated both daylight and colour television, demonstrations on similar lines were staged in the U.S.A., but, as in other cases, to Mr. Baird must be accorded the credit of accomplishing them first.

This was followed almost immediately in August, 1928, by a demonstration of television in stereoscopic relief. The remarks of Professor Cheshire, C.B.E., A.R.C.S., F.I.P., writing in the September, 1928, issue of the *Television Magazine*, are worth quoting—

These pictures, when viewed by an ordinary stereoscope, gave a picture in relief of the object—a human head—transmitted. In this simple way has another milestone been passed on the way to the achievement of that magical combination of the wireless transmission of perfect hearing with that of perfect seeing.

The B.B.C. and the Baird Co.

After a year of bitter controversy between the Baird Co. and the British Broadcasting Corporation as to the commercial practicability of television, the questions as to whether television could be broadcast inside the normal broadcasting band, as allotted to public service stations, and as to whether a separate wave-length was required for synchronizing, were finally and definitely settled when the Baird Co. gave a demonstration of television through 2LO, before a representative committee of the engineers of the Post Office and B.B.C.

Sir John Ambrose Fleming Sitting Before the Television Transmitter, when the B.B.C. Inaugurated Television Transmissions from 2LO, on 30th Sept., 1929

and Members of Parliament. Television was received on portable "televisors" both at the Post Office and at Savoy Hill, no separate synchronizing signal being transmitted, and only the ordinary broadcast service channel as used for speech being employed—thus establishing once and for all that television could be broadcast under commercial conditions. This demonstration was hailed by the Postmaster-General and his Committee as "a noteworthy scientific achievement."

An Inaugural Ceremony

Finally, bringing our brief historical review up to the present date—

On 30th September, 1929, the lengthy negotiations between the B.B.C. and the Baird Co. were brought to a successful conclusion, and an experimental television service through 2LO was inaugurated.

The event was made the subject of a special programme, the details of which we give below—

11.4 a.m. MR. SYDNEY A. MOSELEY, opened the proceedings with the following announcement—

LADIES AND GENTLEMEN: You are about to witness the first official test of television in this country from the studio of the Baird Television Development Company and transmitted from 2LO, the London station of the British Broadcasting Corporation.

On this inaugural occasion we are very fortunate in having with us Sir Ambrose Fleming.

I must explain that as the facilities for broadcasting both *speech and vision simultaneously are not yet available*, we shall transmit first of all speech, and afterwards those of you who have televisors will have an opportunity of seeing the speakers. Listeners not yet in possession of televisors should leave their sets tuned in, in the ordinary way.

Before asking Sir Ambrose to address you, I have a message from Sir William Graham, the President of the Board of Trade, which I shall read to you.

Message from the

Rt. Hon. William Graham, P.C., M.A., LL.D., M.P.

President of the Board of Trade, Member of the British Cabinet

It was with great pleasure I received the invitation to speak and be seen on this occasion of the first public experimental broadcast of television, and I deeply regret that circumstances prevent me from being present.

I look to this new applied science to encourage and provide a new industry, not only for Britain and the British Empire, but for the whole world.

This new industry will provide employment for large numbers of our people, and will prove the prestige of British creative energy.

In this first public broadcast, we have a beginning which will be historic in the evolution not only of a science, but of an art which will encourage closer relations between communities at home and abroad and provide a new avenue for educational development.

11.8 a.m. Announcer: Sir Ambrose Fleming will now be televised for two minutes.

11.10 a.m. Announcer: It is now my pleasure to call upon Sir Ambrose Fleming to address you. It is hardly necessary for me to say that it was due to the untiring work of Sir Ambrose, in the early days of wireless, that radio broadcasting, as we understand it to-day, has become possible. Now Sir Ambrose Fleming will say a few words.

Sir Ambrose Fleming: As President of the Television Society, I have great pleasure in saying a few words of congratulation both to the Television Company and to the British Broadcasting Corporation on the inauguration of a new departure in the art of television. It will, I am sure, contribute to the pleasure of countless persons and assist in the creation of a new industry which owes so much to the genius of Mr. Baird.

11.12 a.m. Announcer: Professor Andrade will now be televised for two minutes.

11.14 a.m. Professor E. N. Da C. Andrade: I am glad to be able to take part in this interesting experiment, which may be compared with the occasion on which the records of the early phonograph were publicly tried. The voices that then issued from the horn were not of the clarity which we now expect, and the faces that you will see to-day, by Mr.

Capt. O. G. Hutchinson, who, with Mr. Baird, is Joint Managing Director of the Baird Television Development Co., Ltd.

Baird's ingenious aid, are pioneer faces, which will, no doubt, be surpassed in beauty and sharpness of outline as the technique of television is developed. One face, however, is as good as another for the purpose of to-day's demonstration, and I offer mine for public experiment in this first television broadcast.

ANNOUNCER: Now we come to the second half of the proceedings, which I fancy will be in a rather lighter vein.

11.16 a.m. SYDNEY HOWARD: Televised for two minutes.

11.18 a.m. SYDNEY HOWARD: Gave a comedy monologue.

11.20 a.m. MISS LULU STANLEY: Televised for two minutes.

11.22 a.m. MILL LULU STANLEY: Sang "He's Tall and Dark and Handsome" and "Grandma's Proverbs."

11.24 a.m. MISS C. KING: Televised for two minutes.

11.26 a.m. MISS C. KING: Sang "Mighty like a Rose."

11.28 a m. MAJOR A. G. CHURCH, M.P.: This is the first official occasion on which the features of living persons have been transmitted through the British Broadcasting Corporation's station by arrangement with the Baird Television Development Company.

It is a great occasion, and one on which it is a great privilege to be present. As the General Secretary of the Association of Scientific Workers, I welcome this triumphant application of science to life. Mr. Baird's is a comparatively new invention. He does not assert that the images which you who are in possession of "televisor" receivers see, are the final product of his brain, or those of other inventors interested in the development of this new means of communication. You yourselves will appreciate the nature of his triumph. You will not be satisfied until you can have transmitted to you visible images of activities in which so many of us are interested; for example, a classic horse race, the boat race, a football match, or a great public ceremony.

We have heard recently a great deal about conversations across the Atlantic. The development of television will enable people not only to converse over great distances, but also to see each other at the same time. The influence this may have upon the relations between the heads of States throughout the world is incalculable. It must be beneficial.

I desire to congratulate Mr. Baird warmly on the success which has attended his efforts. I should also like to express the hope that those who wish to see this new industry developed, and television must be regarded as a new industry, will, so soon as possible, install a receiving apparatus in their homes.

Television Transmissions Successfully Received in the Provinces

By the time this book reaches the public, "televisors" should be available to all. Meanwhile, reports as to the results obtained in various parts of the country are most encouraging. As indicative of what can be done, extracts from a column appearing in the *Bradford Telegraph and Argus*, dated 8th October, 1929, will no doubt serve as a valuable guide—

History was made in Bradford to-day. Television transmissions from London were received in Bradford.

In simpler language, a man, easily recognizable, was seen to be making grimaces and turning his head despite the fact that the man was in London and the witnesses in Bradford.

A *Telegraph and Argus* reporter was privileged to-day to witness this, the first wireless transmission of television to be received in the provinces from the B.B.C. London Station.

Mr. H. J. Barton Chapple was in charge of the experiment, and was assisted by Mr. Sidney R. Wright, of Bradford, at whose home at Nab Wood the experiment was conducted.

The first difficulty was in securing the London transmission at loud-speaker strength—wireless enthusiasts will appreciate this. This part of the task was in the hands of Mr. Wright, who succeeded with the aid of a screened grid set in securing sufficient strength.

This set was coupled with another three-valve amplifier which carried the output to the portable "televisor," which was manipulated by Mr. Barton Chapple.

At 11 o'clock the announcement was made that the television transmission was to commence. The loud-speaker was switched off and the "televisor" switched on.

Through an aperture measuring, roughly, four inches by two—it can, of course, be enlarged to suit requirements—dots of orange light appeared. Quickly the dots flashed past the eye until nothing but a square of orange light was to be seen.

An adjustment here, and then the dots formed themselves into the shape of a man's face. Another adjustment, and then the face became recognizable.

Enthralled, the three or four people in the room watched this individual as he turned his head first to one side and then the other, opened his mouth, raised his eyebrows, laughed

Mr. H. J. Barton Chapple (seated) Giving the First Wireless Demonstration of Television to be Received in Bradford from the B.B.C. London Station

and scowled. It was difficult to imagine that this vision was being flashed 200 miles through the air. The man disappeared.

In its place there came another vision. Still a man's face, which in a moment was easily recognizable as a profile of the Prince of Wales. He was without a hat, and his collar and tie were easily seen.

Listeners who know the difficulty in getting the London transmission will realize that a distinct triumph was secured in attaining such excellent results, and it is evident now that television has reached such a stage as to be of great entertainment value.

It should also be added that the transmission and reception was in full daylight.

Sufficient conclusive proof has now been furnished to indicate exactly when Mr. Baird gave to the world the products of his fertile brain, and it is to be hoped that the collation of these reports will accord to this British pioneer the status which is his by right in the successful development of commercial television.

CHAPTER II

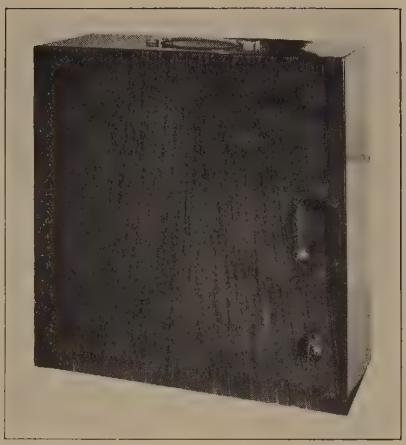
THE GENERAL DETAILS

A PERUSAL of the preceding chapter, dealing with the historical progress of Baird television, will have whetted the appetite of the reader for more details of a new science which must, in its final achievement, impinge upon our daily habits. Living in an age of miracles, we are inclined to take so much for granted. For the moment at any rate television is regarded with either incredulity or scepticism. This book will enable the reader to come down to brass tacks.

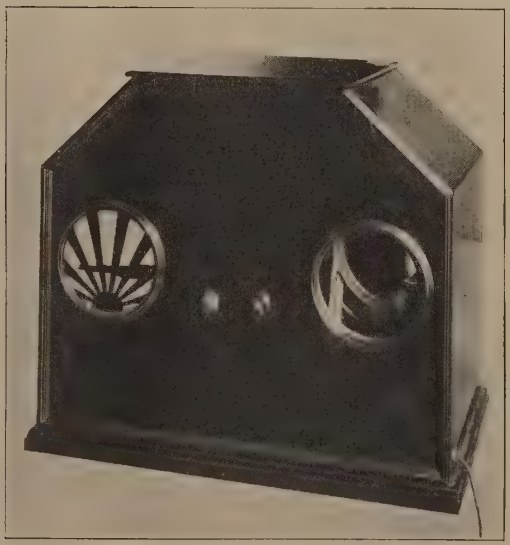
First-hand Information

The authors' intention is to place in the hands of the public the most up-to-date, first-hand information concerning the Baird system of television. Unfortunately, much information published is useless. Readers of the book may acquaint themselves with the apparatus and theory without having to spend time in reading about "obsolete" methods which, while reflecting credit on the efforts of the designers, have failed to stand the test of practical working under everyday conditions. What succeeds in the confines of the laboratory may be valueless outside.

While it is never wise to run before one can walk, the best purpose will be served in reviewing briefly the system as a whole, so that the general scheme will be plain; for this is the best condition of the mind for absorbing the more detailed explanations of the apparatus used in achieving this reproduction of sight.



One Form of "Portable" "Televisor" Used for Demonstration Purposes



One of the Earlier Models of the Dual Baird Machine

The picture is seen on the right while the loud speaker is behind the left-hand grille

A Definition of Television

First, a simple definition of television. By the aid of television we can visually witness what is happening at some distant place, just as if we were eye-witnesses on the spot. In its strictest sense, we can define *true television* as the ability to see, with the aid of electrical methods of transmission, a reproduction on a screen of the image of moving or stationary objects situated at any distance from the observer.

Of course, as we shall see later in the book, there are countless ramifications which broaden the possibilities of the scheme, but that in no way alters the definition.

Now, is this seeing by means of land line cables or wireless any more complicated than listening on the telephone, or hearing by wireless? At the present stage of the development of the science it would be foolish to reply in the negative; but let it be said immediately that the extra complications are only of a relatively minor order as far as the actual operator at the receiving end is concerned. This point should never be lost sight of by the amateur.

Does Any Relationship Exist?

Is there any relationship existing between aural broadcasting as we know it to-day, and the transmission and reception of television? Yes, there is, and that is why the progress in this science has been more rapid than one at first would be led to expect.

When a voice is being broadcast from a wireless transmitting station, the person stands or sits before a sensitive microphone, somewhat similar in principle to the mouthpiece of an ordinary desk telephone, and the sound waves produced by the voice are converted by this mechanism into varying electrical impulses. These minute variations are then amplified and made

to modulate, that is, they are superimposed upon the high frequency carrier wave of the station, and pass into space from the transmitting aerial as electro-magnetic waves radiated in every direction.

These "wireless waves" produce extremely small voltages in the receiving aerial tuned to the transmitting station's wave-length, and these are amplified and rectified by the wireless receiving set, passing finally to the loud speaker, where they are again reconverted into sound waves. Providing the receiver and associated apparatus are of sound design, they act as an agent whereby an aural replica of what is happening at the distant studio is reproduced in the home, but they appeal to one sense only, namely, hearing.

Conveying Complete Intelligence

What modifications are necessary to enable us to bring into being our sense of sight instead of letting it lie dormant? To convey *complete* intelligence, it is no good relying upon speech alone any more than it is wholly satisfactory to have sight alone and be dumb. Some may query as to which of these two senses is of greater importance, but no one will deny that both together ensure a proper understanding. For that reason alone the addition of sight to our existing broadcast or telephoned speech is of the utmost importance, whether viewed from the entertainment, educational, or commercial angle.

Now, in the Baird television system, the person to be televised stands or sits in front of four light-sensitive or photo-electric cells. These cells, as we shall see later, have the wonderful property of responding in an electrical sense to varying amounts of light and shadow, and converting them faithfully into electrical variations of corresponding strength. In other words, they can be

THE BAIRD TELEVISION STUDIO AT LONG ACRE, LONDON, W.C.2

The person being televised is seated before the aperture in the draped wall

looked upon as acting in the nature of a very efficient light microphone, in a somewhat similar manner to the speech microphone.

Located behind these cells, but in front of the televised object, there is an optical apparatus consisting of a rapidly revolving metal disc, around whose periphery is arranged a series of 30 holes in the form of

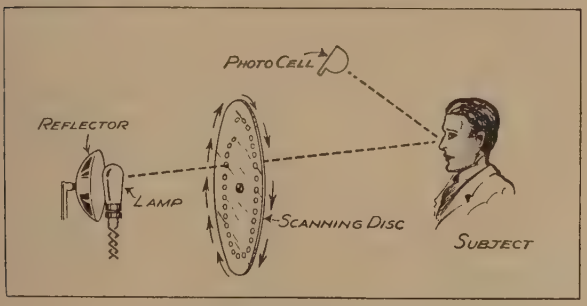


FIG. 1. A PICTORIAL IMPRESSION OF HOW TELEVISION TRANSMISSIONS TAKE PLACE

a spiral. Through these perforations are focussed rays of light from a high candle-power lamp, so that they are projected upon the person sitting in front of the apparatus. A reference to Fig. 1 will give an impression of what has been described.

The Work of the Photo-electric Cells

Owing to the revolving disc, the narrow pencils of light pass over the person's face and subdivide the features into a number of strips, and it will be seen that every part of the face is successively illuminated by a small point of light, the speed with which this process takes place being dependent upon the disc revolutions per minute. Depending upon what part of the face the light spot is moving over, so a variation of light and

shade is thrown back or reflected on to the photo-electric cells. Thus, on the forehead a considerable amount of light would be reflected, whereas, when the spot traversed black or dark hair very little light would be thrown back. According to the amount of reflected light picked up by the cells, so it is converted into electrical currents of proportionate amplitude, and, therefore, as the spot of light makes a complete traversal of the subject image, a current of varying intensity is sent out from the cell. No personal discomfort is experienced by the person being televised, and the resultant current variations, owing to their minute nature, have to be amplified and then made to modulate a high frequency carrier wave at the transmitting station, and finally are propelled into space as waves similar to the speech waves. Any one tuning in their wireless set to this transmission will be rewarded with a distinctive note emanating from the loud speaker —something like a high-pitched drone.

A Process of Conversion

The next point that arises, of course, is how can we reconvert this to a plainly visible reproduction of the person at the studio, knowing that the television electric eye in the shape of photo-electric cells has provided the gradations of light and shade that enable us to distinguish form?

To digress for a moment, have you ever tuned in a strong signal on your wireless set, and then substituted a neon lamp—one of the familiar beehive pattern will do for this purpose—for the loud speaker? If this is done, the signals become visible instead of audible, for the set-owner would see the flickerings of the lamp in place of hearing the vibrations of a diaphragm. But supposing you had tuned in a television transmission,

what then? Why, the flickering of the lamp with the varying signal intensity is reproducing the reflected light from the original object.

Forming a Picture

All that remains is to arrange the series of light flashes over a surface or area corresponding to that occupied by the object. That is, a picture must be formed out of the succession of light and shade, just as the artist forms his picture from a succession of brush touches on a canvas, bearing in mind that we are to take advantage of the peculiar property of this neon lamp, which responds instantly to the varying currents in the output circuit of the last valve of the wireless receiving set.

Obviously, our requirements call for a duplication of the transmitter scanning disc, that is, it must have the same number of holes as the transmitter disc, although its size can be adjusted to any proportional dimension. Another factor is that both the transmitter and receiver discs must revolve in synchronism, or, in simpler language, the discs must run at the same speed and be in the same phase relationship. The extreme importance of this item (indeed, we can regard it as the crux of our television system) will be gathered when attention is turned to the detailed description of synchronizing in Chapter V.

The Picture Canvas

Provided these conditions are satisfied, and regarding the glowing plate of our neon as the canvas for our picture, then with the receiver disc revolving in front of the neon, the light from this lamp passes through the holes of the disc and reach the eyes of the observer.

When the first hole of the transmitter disc explores a line across the object, and lets the beams or pencils of light fall in succession on the photo-electric "microphone," so the receiver disc has a hole which explores a line across the glowing plate of the lamp, and it is seen bright in one spot and brighter or darker in another as it flickers.

There must be perfect synchronism between the two discs, so that the line viewed across the glowing plate varies in light intensity exactly as does the line explored across the object. A succession of such lines side by side will make an image having the same gradations of light and shade as the original object, owing to the phenomenon known as "persistence of vision." This natural property of the eye makes the whole image appear simultaneously, and resembles that of the principle whereby in cinematography, owing to the rapidity of motion we view one moving continuous whole, and not a succession of still pictures.

Creating Form from Strips of Light

Our previously disintegrated object is now reintegrated, and built up completely by the succession of impulses we have spread over a surface, thus creating form. It must be carried out quickly enough—generally at the rate of $12\frac{1}{2}$ complete picture explorations in one second, corresponding to a speed of 750 revolutions per minute—so that the eye does not have the opportunity of dwelling on the mechanics of the process, but sees only the flashes in their proper place, rather than as a sequence.

We can look upon the revolving disc and neon lamp which recreate the image as serving the eye in a similar manner as the loud speaker serves the ear, and just as in the case of a first-class wireless receiver and associated

LIEUT.-COMMANDER W. W. JACOMB, R.N.

Chief Engineer of the Baird Companies, whose work in the past few years has been in research and development

loud speaker, we are struck with the quality of reproduction as judged by the ear, so with television one cannot fail to appreciate the beauty of detail as revealed to the eye.

The Co-operation of Amateurs Needed

Have you paused to consider the vastness of the new field of investigation opened up to the amateur? Bear in mind that the unstinting efforts made by amateurs in the early days of wireless, contributed in no small measure to the rapidity of progress made in wireless transmission and reception, and undoubtedly with television the aid of the experimenter will be enlisted. The collation and analysis of reports, either of individual research or of the reception of television transmissions, under a variety of climatic conditions and environment, will be instrumental in furnishing valuable data to the authorities and companies responsible.

What further inducement is needed to make all desirous of examining the problems with whole-hearted endeavour? The race to perfect television is gathering apace. First honours to us, for it was a Scot who first achieved real television. Let it be through the co-operation of British amateurs that this new science forges ahead and makes its presence felt throughout the world.

CHAPTER III

THE BAIRD TELEVISION TRANSMITTER

In the last chapter we took a rather condensed survey of what actually happens in the process of real television. It is now essential to concentrate on detail, and follow the whole scheme from beginning to end, to ascertain the purpose and normal function of each piece

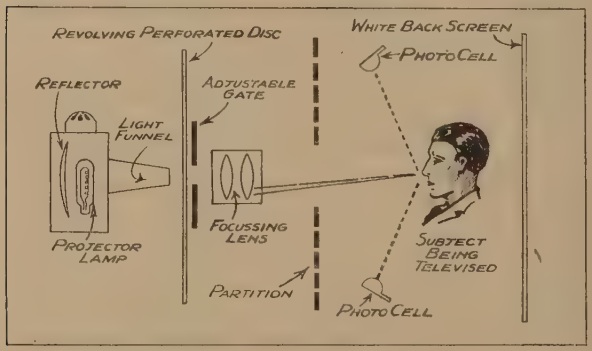


FIG. 2. THE ELEMENTS OF THE BAIRD TRANSMITTER

of the apparatus. To do this we must devote our attention first of all to the transmitter.

Obviously, our first requirement is a source of illumination, and since the rays of the light must be forced through the small holes of a revolving disc, it follows that *the lamp must be capable of great brilliancy* and be as concentrated in illumination as possible.

This is mounted in a metal projector cover complete with chimney and funnel.

Behind the lamp is secured a concave reflector, and it must be possible to move this reflector in every

direction with reference to the light source, so that the focussing lens (see Fig. 2) is " filled " with light.

Introducing the Scanning Disc

When the rays of light emerge from the projector funnel they play upon a flat metal disc, purposely made

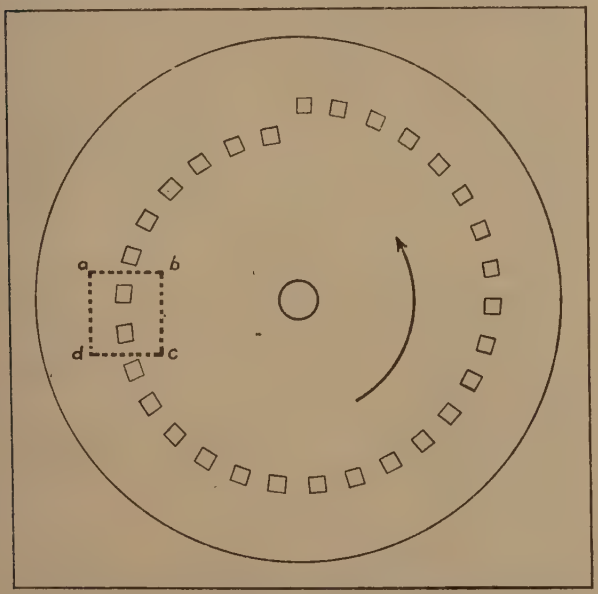


FIG. 3. THE SMALL SQUARE HOLES IN THE SCANNING DISC SHOWING THE SPIRAL ARRANGEMENT

heavy, so that when run up to normal speed it tends to remain running at this speed owing to an inherent flywheel action

This scanning, or exploring, disc, as some people prefer to call it (let us hope television nomenclature will be standardized in the near future), is specially

constructed in so far as it has 30 square holes pierced through the disc.

The perforations *have equal angular displacements around the periphery*, and are arranged in the form of a spiral somewhat as shown in Fig. 3.

We shall revert to disc details later, since this item is of extreme importance.

By correctly mounting the disc, the beam of light can throw a ray through each hole, as it sweeps through the light area *abcd* of Fig. 3 when the disc is revolving. The disc is driven by a very efficient constant speed shunt motor, any necessary speed variations being made through the medium of a shunt resistance mounted on the transmitter table.

A Standard Form of Baird Transmitter

Naturally, this sweeping light ray *must be focussed on the subject being televised*, and the inclusion of a focussing lens (see Fig. 2) enables this to be effected with extreme accuracy.

The object scanned is placed in front of a large white screen, and the lens adjusted to the best mean focus according to the distance separating the disc and object.

Now, of course, we must so place our photo-electric cells that they are influenced by the light reflected from the object, and, according to the type of cells used, and the size of the scene televised, they are placed above and below the object.

This is shown diagrammatically in Fig. 2.

One of the accompanying photographs also shows a complete projector stand, which has been standardized and used by the Baird Co. for quite a long time now.

It is usual to partition off the televised object and photo cells from the projector itself, and arrange that *no*

A Photograph of the Transmitter with the Amplifier Boxes and Controls Housed on an Adjoining Table

direct light, other than that of the travelling light spot, plays upon the object.

The reason for this will be obvious, for it is essential to have the photo-electric cells influenced only by the light reflected from the spot purposely illuminated.

The Number of Disc Holes

Now let us consider the disc itself for a moment.

First of all, as to the number of holes. Baird, after considerable experiment in the early days, *decided upon the number of* 30, and it is interesting to note that the German Post Office has adopted this as standard in that country.

In the United States of America, we have Jenkins using 48 holes, and this number is advocated by the Radio Manufacturers' Association of America. The General Electric Co. uses 24 holes, and the Radio Corporation of America go to the other end of the scale and take 60 as their standard.

Naturally, we shall have the 30 holes standard in this country, at least to start with, and as we shall see later, since the detail of our resultant picture is limited by the sidebands allowable to each broadcasting station by the Prague plan (9 kilocycles at present), it is obvious that there must be an optimum value in the number of holes best suited for this detail. It is, therefore, somewhat extraordinary that this optimum value should prove to be obtainable with exactly the same number of holes as used by Baird in his earliest days, namely, 30, and furnishes further evidence of the far-seeing character of the inventor's deliberations.

Correctly Shaping the Disc Holes

What of the shape of the hole? Are the best conditions met by one of a peculiar shape, or will a standard

hole satisfy? Looked at from the point of view of the passage of the greatest amount of light for a given area, a square hole is best suited, and in actual practice this is employed.

On the other hand, if we remember that there is a spiral formation used for positioning the disc perforations, then theory demands a slight wedge shape with curved inner and outer edges, together with a slightly decreasing area for each hole, as we pass from that nearest to the disc periphery to that farthest from it.

Any one with a mechanical turn of mind will agree that to stamp or punch out disc holes to this degree of precision is not a commercial proposition, and, indeed, if it were, the advantage over a standard sized square hole would be imperceptible.

Graduated Exploration

There are many experts working in the field of television, particularly in America, where they content themselves with round disc perforations. To our mind, however, the square hole is the best.

With the detail limited by the sideband available as mentioned previously, the Baird Co. have developed what may be termed "graduated exploration." With this the transmitting disc has three rectangular holes at the beginning and end of the spiral; that is, at the outer and inner edges of the light area. Square holes are used for the remainder, and by this means the grain on the outside of the picture is coarser than the grain at the centre. This gives the effect of concentrating the available detail to some extent in the centre of the picture, where it is most useful. It is claimed quite rightly that this scheme uses the present allocated kilocycle sideband to the maximum effect, and is therefore of great importance.

A Standard Form of Television Transmitter Used by the Baird Co.

The Shape of the Light Area

Picture what happens now as our disc revolves. According (*a*) to the distance separating the lens from the background, (*b*) the difference in radial length between the first and last hole, and (*c*) the circumferential distance between each disc hole, *so we shall have a definite light area covered on the screen.*

Its shape will be somewhat as indicated in Fig. 4, the picture ratio being 7 to 3.

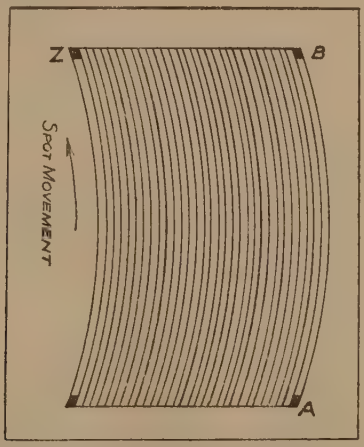


FIG. 4. SHOWING HOW THE "LIGHT AREA" ON THE BACK SCREEN IS MADE UP OF STRIPS OF LIGHT

A "gate" or mask is arranged as close to the disc as possible, and consists merely of two metal shutters, one of which moves up and the other down, and this governs the height, or, shall we say, depth, of the light beam.

With the fixed light source and the moving disc, the actual object is scanned by the spot of light moving from right to left and bottom to top. In other words, starting in the bottom right-hand corner (*A* of Fig. 4),

and finishing at the top left-hand corner (*Z* of Fig. 4). According to the position of the projector lamp on the right or left of the scanning disc motor, so the motor will have to revolve clockwise or anti-clockwise to give this effect, bearing in mind, of course, that the focussing lens actually reverses the light spot direction.

The first light strip traversed is that shown as *A B*, and it is necessary to adjust the "gate" so that one hole just leaves the screen at the top a moment before another appears at the bottom. In other words, the gate depth is slightly less than the distance between two adjacent holes, thus giving a condition that for a very short time there is no spot on the screen at all.

The reason for this will be made clear in Chapter V, on "Synchronism."

Overcoming Flicker

Our second hole in the disc, therefore, describes another light strip immediately adjacent to the first strip, and with each complete revolution we produce an illuminated area, shaped as in Fig. 4.

If the disc is revolved slowly, then naturally we can follow the light spot movements across the screen, but at the normal running speed of 750 revolutions per minute there is practically no perceptible flicker—the area appearing as being flood lighted, owing to the speed of the operation, just as the rapidity of the changes in alternating current prevents discernible flickering in an ordinary electric lamp.

How Black and White Lines Appear

The reader will see now how necessary it is for the square holes in the exploring disc to be accurately positioned.

There must be no underlapping or overlapping

between the outer edge of one hole and the inner edge of the following hole; otherwise the junctions between the light tracks become visible.

A reference to Fig. 5 will show exactly what is meant.

Taking the holes marked 1 and 2, it will be seen that the track made by the inner edge of the first hole does not quite meet the track made by the outer edge of the second hole.

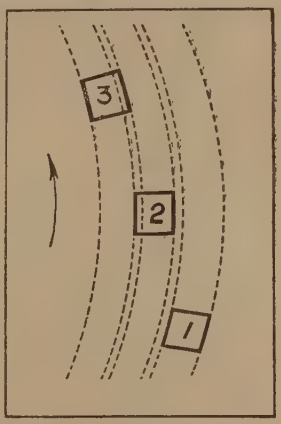


FIG. 5. INDICATING HOW UNDERLAP AND OVERLAP CAN OCCUR WITH INACCURATE HOLE-POSITIONING ON THE DISC

This will cause a thin black line to appear on the screen, its width depending upon the amount of underlap.

On the other hand, with holes 2 and 3 we have overlap, and *this will result in a narrow white line making its appearance.*

Unless the errors are gross ones, however, these black and white lines are not very conspicuous, but they enable one to judge the degree of efficiency with which the disc has been made.

So far so good; for it is to be hoped that the reader will have grasped how the travelling light spot is made to function.

Meet the "Television Eye"

The next point that arises is whether it is necessary to resort to such a scheme in order to televise, say, the features of a living artist.

The object upon which the dissecting light strip plays

will naturally reflect a certain small proportion of this light—the exact amount depending upon the colour, nature, and contours of the reflecting surface.

How can we convert this reflected light into some form of intelligible electrical variation, which, in turn, can be made to modulate the high frequency carrier wave of an ordinary wireless broadcasting station?

It is here that we make our formal acquaintance with the "television eye," as it is sometimes popularly called, or the "light microphone," as we referred to it in the last chapter.

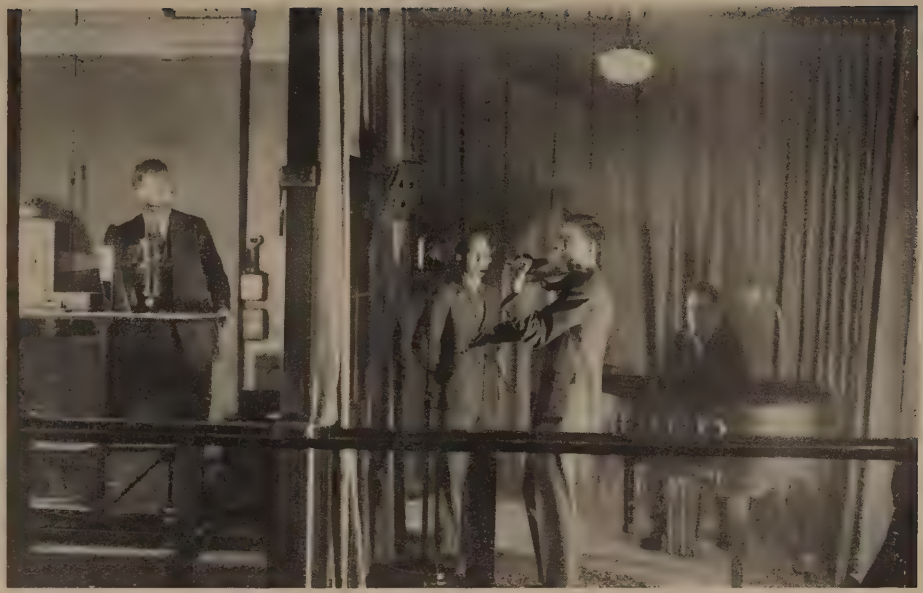
Since the principles of photo-electric cells are dealt with fully later on in the book, we shall confine ourselves to a passing comment on their function.

Selenium Unsuitable

No doubt many readers can recall the discovery, made some years ago now, of a substance called SELENIUM. This had the peculiar property of responding in an electrical sense to light and shade; that is to say, if it were connected up in a circuit and exposed to light, a current would flow in the circuit of which it formed a part, but on shielding the selenium from the light rays the current flow would cease.

Furthermore, the magnitude of the current flow was dependent upon the amount of light to which the selenium was exposed.

What a vista to the science of television this new field of enterprise opens up! That must have been the first thought of scientists who made investigations into this substance of selenium. Unfortunately, their hopes have remained unfulfilled. There is a time lag or inherent sluggishness in the response of the current flow to light exposure, and although many ingenious schemes have been propounded in an effort to cure



A Transmission in Progress at the Television Studios and Transmitting Room of the Baird Television Corporation of America in New York City

this trouble, they have not met with any measure of success.

Television demands the reduction of this time element factor to a zero quantity.

The science, therefore, laid dormant until photo-electric cells made their appearance on the scene, and put an entirely different complexion on the whole question.

These cells, while possessing the same property of current flow to light exposure, *are instantaneous in their action*, at least so far as modern methods of measurements have been able to tell.

The Reason for Using a Travelling Light Spot

While the magnitude of the resulting current for a given light flux is considerably smaller than with selenium, this is counterbalanced quite easily by pressing into service a multi-stage valve amplifier which can be made to increase the current variations to almost any strength desired.

A moment's thought should be sufficient to convey to the reader the absolute impossibility of one or more photo-electric cells converting an entire scene or image into terms of electrical current variations.

There are far too many differing light values spread over the area within its compass, and in consequence we have to analyse our subject to be televised into a large number of elemental areas.

These areas will each possess a definite reflected light value when illuminated by the travelling light spot, and the cell is then capable of responding to each light value in turn.

This gives us the reason for adopting the BAIRD TRAVELLING LIGHT SPOT.

At one instant we have a minute square area illuminated, and the reflected light produces a current variation in the circuit containing the one or more photo-electric cells.

Hearing the Television Note

At the next instant, the actual time taken depending upon the speed with which the disc rotates, an adjacent elemental area in the light strip is illuminated, and our cell makes an instantaneous response.

This process is continued, spot by spot and strip by strip, until *the whole of the area has been disembodied into values of light and shade and corresponding current values until one complete picture conversion takes place.*

We have, therefore, a definite number of current variations flowing in the cell circuit, which can be actually heard in a pair of telephones as a " musical " note.

Of course, the larger the number of elemental areas into which we can dissect our televised object, the greater will be the detail in the received picture. Really, however, it is astonishing how even a coarse-grained picture possesses sufficient detail to make it immediately recognizable and intelligible to the observer.

This is all very well, you will say, for an object or scene which is quite steady, but *what happens when movement is imparted to the subject*? Obviously, the greatest proportion of subjects we shall see through the medium of television will have life, and thus not remain stationary.

Imparting " Movement " to the Televised Subject

The condition is fulfilled very simply *by arranging the speed of the disc to give at least* 10 *complete explorations in one second.*

In practice, 12½ pictures per second is the usual number, corresponding to a disc speed of 750 revolutions per minute, and if this is done the human eye, which is characterized by an inherent lag in its response to light, will observe what is practically a harmonious movement with negligible flicker, instead of a number of still pictures rapidly displayed.

We are familiar with a similar process in ordinary cinema photography, and at this speed the mechanics of the process are lost on the observer.

So much then for the *modus operandi* of the transmitter itself.

The discriminating reader will now be anxious for elucidation on the conflicting reports he has heard concerning possible distortion in the television picture, where it is likely to arise, and if it is serious.

Although this side of the question is wrapped up in both the transmitting and receiving ends, it is felt advisable to dispose of the question at this juncture.

Criticism Based on False Foundations

Unfortunately, most of the criticism levelled at television has emanated from sources or individuals who have examined the matter entirely from a theoretical standpoint, and for reasons best known to themselves have not sought enlightenment in the form of a practical demonstration.

This state of affairs is to be deplored. It places them in a false position as critics, and, while criticism of a constructive nature is valuable, anything of a destructive nature, based on false foundations, is likely to do harm unintentionally.

Now where is television likely to fall short in its aim to give faithful replicas of any transmitted subject?

The answer is, when an effort is made to televise

objects *where the detail is extremely small in relation to the spot of light itself which is projected upon it.*

If the whole of the detail of a body came *within* the bounding compass of the square spot of light, then, obviously, *provided the body was stationary*, the cells picking up the reflected light would tend to produce an object slightly deepened and widened.

Again, consideration must be accorded to the building up and dying away effect in the cells when the light spot encounters and leaves a body having a very sharply defined outline.

There will then be a tendency towards a mean current value, and this in turn will give a somewhat softening effect to the outline.

Are these items in actual practice such as to cause serious defects in the resulting image?

The answer is no.

An Accommodating Human Eye

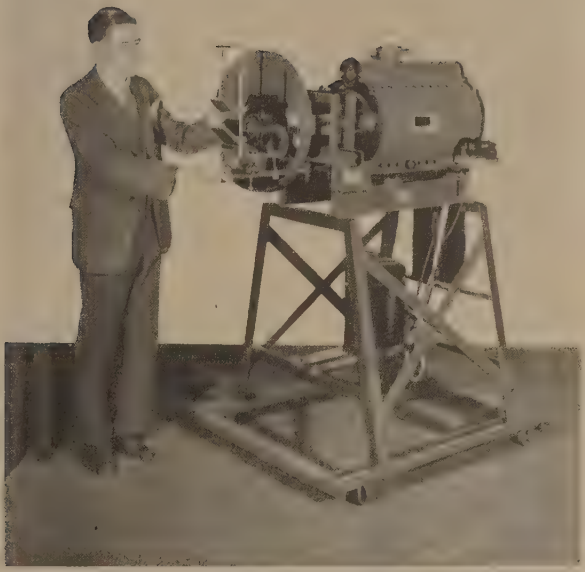
This arises partially from a tolerance and a self-accommodating character of the human eye, and also from the fact that in actual television, as it is being transmitted daily, either at the Baird laboratories or over the wireless, most of the subjects undergo movement.

This gives the light spot and cells an opportunity to perform their natural functions in a faithful manner.

As proof of the smallness of detail that can be shown, it may be mentioned in passing that no difficulty is experienced in noting the position of the hands on a watch!

What methods may be resorted to should it be desired to give still greater detail?

One way would be to *increase the number of holes in the transmitting disc*, and thus make the grain of the screen finer.



A Modern Television Transmitter as Developed by the Baird Television Corporation of America

Showing the periscopic scanner fitted to the machine

Assuming the disc diameter to remain unaltered—for, of course, we cannot go on increasing this beyond a certain economical limit without making the apparatus unduly bulky—then the resulting picture is going to be smaller, owing to the reduction in circumferential distance between holes.

Greater lens magnification would then be necessary to bring the picture up to the size of the previous one.

According to the spiral formation, so the shape of the picture can be altered at will, but this would only tend to introduce complications from the manufacturing standpoint. This must never be encouraged. Rather should the aim be towards standardization, as this will cheapen production and keep down prices.

What of the Frequency Limits ?

Since we have shown that the current resulting from the reflected light variations is extremely minute, it follows that these variations *must be amplified by means of a multi-stage amplifier.*

Here, again, we are faced with an important detail.

A knowledge of the frequency limits is demanded in order to design the amplifier to accommodate them all before *any marked falling off in the amplifier characteristic.*

This is a problem which cannot be dismissed in any light-hearted fashion. The maximum frequency will not only depend upon the number of current values produced in the photo-electric cells in one second, but also upon the number of holes in the transmitting disc, the speed of rotation of the disc, and the shape of the picture.

Since every televised subject brings its own light and shade variations, it will be seen that any mathematical calculation is extremely complicated, and has to take account of the disc dimensions,

Yet in spite of this, and bearing in mind that this little treatise makes no pretensions towards being an *advanced* analytical and mathematical analysis, how can we convince the reader that distortion exists more in theory rather than in fact?

The Dot Theory Fallacious

Any attempt to formulate the dot theory which some have favoured in the past, whereby the picture is treated as being made up of a series of small dots like newspaper illustrations, falls to the ground *owing to the light and shade being distributed throughout the picture in the form of a wash drawing or continuous surface.*

For example, during one period of movement, the light spot may be exploring an area which is wholly or almost black, so that no light is reflected back.

Then, maybe, this is followed by a comparatively long period of white on an object, when we shall have a relatively large current response from the cell.

The actual wave form of our resulting current is, therefore, complicated in the extreme, and due to this we must have a fundamental frequency with a plethora of harmonics if an identical reproduction is required, since it is the combination of a fundamental wave form and the harmonics which together go to make up our peculiar wave form.

Naturally, the lower the cut off of the higher frequencies *the greater will be the rounding off and smoothing over of any sharp contours,* so that very small details are apt to be lost.

With an amplifier which does not cut off below 20 kilocycles, the *wealth of resulting detail is astounding.*

We are, nevertheless, at once up against the 9-kilocycle limit now allowed to broadcasting stations.

Even with this cut off artificially imposed as a result

of deliberations based entirely upon the considerations of aural broadcasting, the detail which comes over is particularly good.

It is to be hoped the interests of regular television services will be catered for at an early date by a special or increased side band allocation.

The Effects of Frequency Cut-off

It is found in practice that the best results are achieved by resorting to relatively low amplification per valve stage with several stages, than to attempt all the amplification desired in two, or perhaps three, stages.

Resistance capacity coupling with certain modifications is advisable.

At the other end of the scale we must not lose sight of the fact that frequencies as low as 20 or 30 will have to be handled, and, in consequence, the transmitting amplifier calls for the exercise of technical skill both in its design and construction.

Should there be any loss of the low frequencies in the amplifiers or the land line to the transmitting station, this will evidence itself in the picture as undesirable dark shadows, while the presence of pure white or any strong surfaces tend to throw these up somewhat.

With a loss of the higher frequencies the picture tends to look rather " woolly," and detail is lost somewhat.

With the present 30-hole Baird disc used in this country, vertical scanning is employed, since it is claimed, quite rightly, that this gives greater detail when televising the subjects which are now possible with the present state of progress.

A certain amount of controversy exists as to whether horizontal or vertical scanning best serves the interests of the science, and in this connection the question of " hunting " has to be considered.

By hunting we mean any to-and-fro movement of the picture for horizontal scanning, and up-and-down movement for vertical scanning.

Vertical Scanning Best

We are fairly well accustomed to moving our heads from side to side somewhat quickly. Indeed, most of our everyday movements take place in a horizontal plane, but when we see these natural movements made artificial by the increased movement imparted by the horizontal hunting, it appears very marked and almost ludicrous. With vertical scanning the combination of the vertical picture movement with the horizontal natural movement gives a rounder or smoother effect to the eye.

Hunting, therefore, in a *horizontally explored television image* tends to become a more noticeable feature than is the case with vertical scanning.

Anyone who has had the opportunity of witnessing both methods of exploring can prove this peculiar feature for himself.

Having efficiently amplified the signal impulses emanating from the travelling light spot, they are made to modulate the high-frequency carrier wave of the transmitting station in a similar manner to speech currents from a microphone.

They are then broadcast into space.

We must now transfer our attention to the receiving end, and see what has to be done in order to reassemble the disembodied pictures and make them visually intelligible.

CHAPTER IV

THE BAIRD "TELEVISOR" RECEIVER

So much for the transmitter, which we hope has been presented in a sufficiently simple form to enable the reader to understand the subject.

And now, what about the receiver, which, from the point of view of the average reader, is the more important?

It is the receiving set which, after all, is going to be installed in every home, and about which the amateur will manifest the greatest interest.

Revealing the Secrets of the Mechanism

Let us see whether we cannot offer the reader some simple explanation of this part of the problem.

We have seen that the trains of impulses, representing the electrically dissected image from the transmitter, are broadcast into space as a modulated carrier, or sent along a land line.

It now becomes necessary to study the means adopted for reassembling the subject at the receiving end.

Naturally, if wireless is the medium adopted for propagating the current pulses, and this is the one that concerns us most, then *a wireless receiving set is called for*. The actual details of this receiver are discussed fully in Chapter VII.

Here, first of all, we purpose examining the "televisor" itself, which, contrary to general expectation, we shall find is *a very simple mechanism in its present form*; far less complicated to handle actually than a normal wireless receiver.

The Essential Parts

The essentials are—

(1) A *scanning disc*, proportionately dimensioned to the one used at the transmitting end, and, of course, possessing its spiral of small square holes.

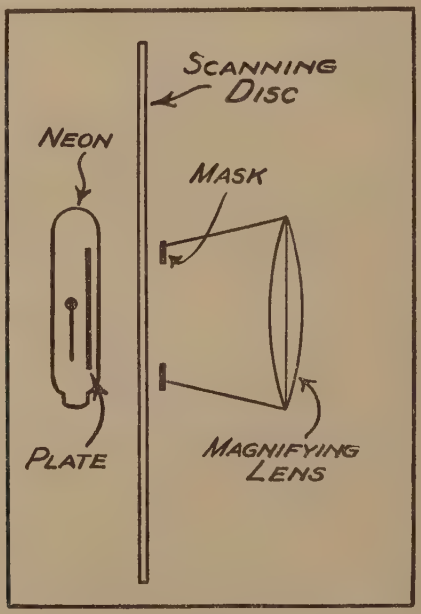
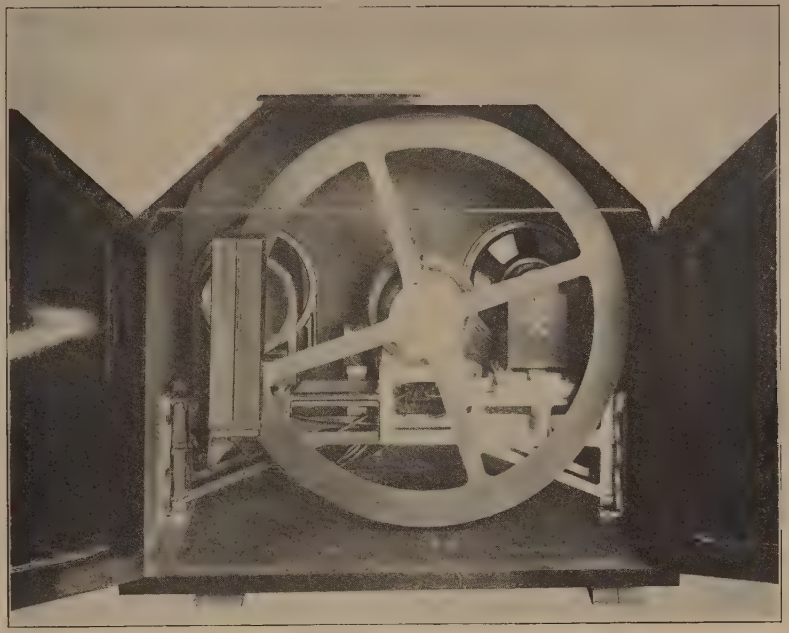


FIG. 6. A SECTIONAL DIAGRAM OF THE BAIRD "TELEVISOR"

(2) A *driving motor* for the disc.
(3) A *synchronizing mechanism*.
(4) A *neon lamp*, with or without metal cowl or hood.
(5) A *framing mask*.
(6) A *magnifying lens* (optional).

The motor should be of the shunt wound type and



THE INSIDE OF A LARGE MODEL BAIRD "TELEVISOR"

capable of developing a speed up to about 900 revolutions per minute, bearing in mind that the normal running speed is generally 750 revolutions per minute. Naturally, the best purposes are served by incorporating a motor capable of running steadily at its synchronous speed for long periods at a stretch.

While, as we shall see later in the next chapter, the synchronizing mechanism has the primary function of ensuring exact speed and phase relationship between transmitter and receiver discs, matters are helped considerably if the "televisor" motor itself eschews any tendency for sporadic speed changes.

The Best Type of Motor

This will lighten the load on the synchronizing mechanism, which after all is only meant to be a form of speed control within limits, and makes no pretence to be anything in the nature of a drive, and hence under normal working conditions any tendency to "picture hunt" will be nullified.

If there is a house electric light supply available, then the motor can derive its power therefrom. To suit both alternating and direct current mains a *universal motor* is ideal, and it is proposed to include this form of motor in many of the commercial "televisors." On the other hand, for those situations without an electric supply, a 6- or 12-volt motor can be employed.

To give a slight idea of the layout of the Baird "televisor" itself, a reference can be made to Fig. 6, together with one or two of the accompanying illustrations, which show different models.

With the vertical scanning employed we have a tubular form of neon lamp with a flat rectangular-shaped cathode which, of course, glows when the appropriate striking voltage is applied across its electrodes.

According to the strength of the signal passing through the wireless receiver, so the intensity of this plate glow is varied, it being appreciated that the neon is connected in the output circuit of the last receiver stage, being either directly-coupled or choke-coupled, as explained in Chapter VII.

Arranging the Components

Immediately *in front of this glowing neon plate*, and revolving at synchronous speed, is the spirally perforated disc, and in order to give a correct picture size, and so that it may block out any stray light from the neon, a *framing mask* with a rectangular hole cut in the centre is placed *in front of the disc.*

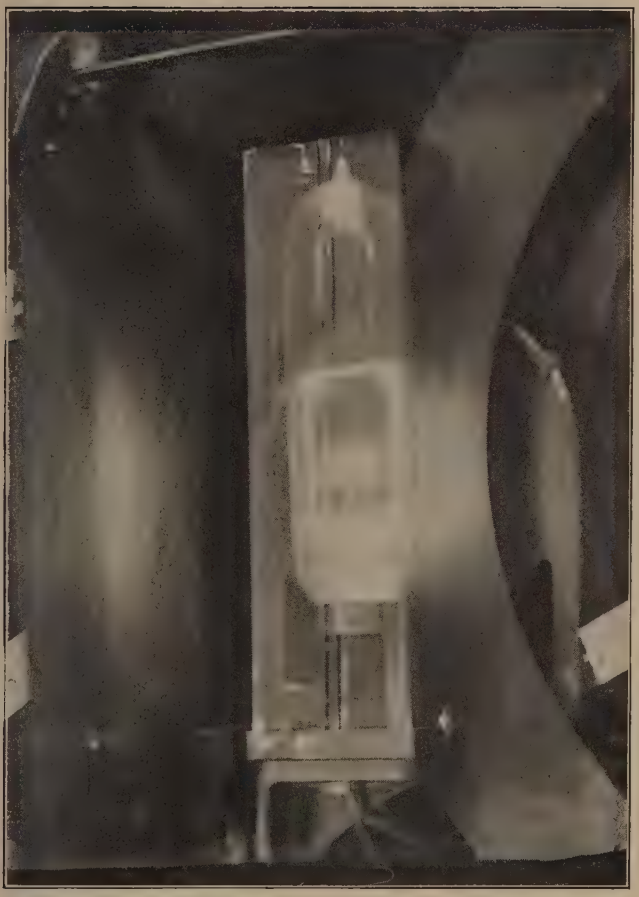
According to the particular model "televisor" in use, a lens is sometimes mounted a *short distance away from the mask* to enlarge the image.

In the illustration facing page 44 may be seen a view of the inside of a large model "televisor," the neon lamp itself in this particular case being housed in a cowl having a rectangular aperture in front.

Provided the transmitting and receiving discs are *in exact synchronism* at any one instant, a perforation or hole in the receiver disc will expose an elemental area on the neon plate, and this will correspond to one at the transmitting end in an exactly similar position. Since the neon glow at that instant is directly proportional to the amount of light reflected from the illuminated spot on the televised object, we shall observe a degree of light or shade of corresponding intensity.

Exposure and Re-exposure

This process of exposure at the transmitting end and re-exposure at the receiving end takes place for each spot and strip, and the resultant effect to a person



A Good Impression of the Glowing Neon Plate being Scanned by the Rotating Disc

looking into the "televisor" is to see this succession of light strips built up into an intelligible picture. As in the case of the transmitter, the process is effected at such a rapid rate that the reproduction has the appearance of a continuous image showing all the movement, light, shade, and contour of the subject sitting before the photo-electric cells.

Now there are one or two interesting facts which must arise in connection with the "televisor," and these it is necessary to explain in the simplest possible terms. Until the reader is made conversant with the causes and the cures of certain little happenings, he is bound to be puzzled, particularly if he be among the uninitiated.

We shall not deal with negative images, since these are a product of the wireless receiving set itself, as explained in Chapter VII, but we will turn our attention first of all to what may be termed "reversals."

A Reversed Effect

It has been pointed out that the televised object is scanned by a spot of light starting in the bottom right-hand corner of the light area, and travelling upwards as a spot direction and from right to left as a strip direction, finishing finally at the top left-hand corner of the light area.

The direction of rotation of the transmitter disc, the position of the projector lamp on the right or left-hand side of the motor shaft, and the reversal of direction brought about by the focusing lens are all properly related to one another to give this standard mode of exploration.

Turning now to the "televisor," it is the practice of the Baird Co. to *mount the neon on the right-hand side of the cabinet*, so that the direction of rotation of

the motor is anti-clockwise with the disc hole spiral cut as shown in Fig. 7A, bearing in mind that the neon is behind the disc. This will ensure that the scanning operation is performed in a manner identical with that at the transmitting end, and our resultant image has normal and correct movement.

What will happen if by error the disc is mounted

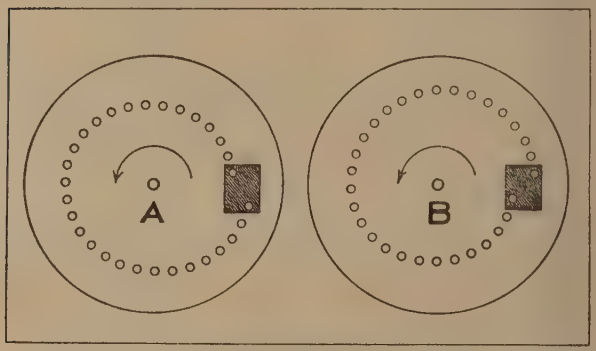


FIG. 7. ILLUSTRATING WHAT HAPPENS IF THE DISC IS MOUNTED THE WRONG WAY ROUND ON THE SHAFT

on the motor shaft the wrong way round, so that the spiral of holes is now in the position as indicated in Fig. 7B? The motor direction is unchanged and also the neon position.

Curing the Trouble

Why, the glowing neon plate will be scanned from bottom to top just the same, but *the spiral movement will be from left to right instead of from right to left.*

If a person, therefore, at the transmitting end moved his head from right to left, in the "televisor" the movement would be reproduced left to right, that is, all horizontal movement would be reversed.

Photo by *Lafayette*

AN HISTORIC PHOTOGRAPH, TAKEN IN 1926, WHEN MR. BAIRD GAVE THE FIRST DEMONSTRATION OF TRUE TELEVISION

This is especially conspicuous when the moving printed script in the form of a news bulletin is transmitted ("telelogography" is the official term applied to this particular use of television), for the letters, since they are moving backwards, look most uncanny, and it is almost impossible to read the message. It is very simple to rectify matters; *just reverse the disc on the motor shaft* and normality is regained.

Then we are sure to come up against the experience of "splitting the picture."

As we shall learn in Chapter V, synchronism between transmitter and receiver is obtained by *running the receiver motor approximately up to its correct speed by adjusting the field rheostat control*, mounted on the front of the "televisor" cabinet, and then the synchronizing device comes into play and holds it there automatically.

FIG. 8. A "SPLIT PICTURE" IN A "TELEVISOR" SCREEN

But supposing the scanning disc is pulled into step when the strips are not in their original order from right to left. To illustrate our meaning, we can imagine the case when the first strip from the right of the neon plate is held in step with, say, the middle strip of the transmitter.

A Peculiarity which Sometimes Happens

Now, since this middle strip of the transmitter is exploring the centre of our televised subject, the results of this exploration will appear as a strip on the extreme right of our "televisor" screen.

The received image will therefore be split down the centre, and will resemble that shown pictorially in Fig. 8.

Of course, this can take place at any relative position of the scanning operation, and to rectify matters the disc speed must be increased or decreased slightly so that it "slips" relatively to the transmitter until the image is correctly positioned in the centre.

A very careful manipulation of the speed control on the motor will bring this about.

In addition to splitting the picture, it is possible to turn it upside down! This is brought about when the neon lamp is mounted on the left-hand side of the "televisor" instead of on the right, the direction of disc rotation being kept the same, namely, anti-clockwise.

A Remote Happening

A reference to Fig. 9 will be almost self-explanatory.

A represents the transmitting end with disc and subject being televised, while *B* shows the receiving end, the "televisor" screen (or neon plate) being shown as the small rectangle on the left of the disc.

The first strip created by No. 1 hole at the transmitting end will explore the extreme right-hand side of the picture, but at the receiving end this will be reproduced by strip No. 16, which, of course, will mean that the picture will start being created at the centre of the neon plate, assuming, of course, that synchronizing has been set for normal working.

Furthermore, hole No. 1 is travelling upwards, whereas hole No. 16 is travelling downwards, and hence our picture in addition to being split is turned upside down as indicated.

A picture would be seen anywhere round the disc

Untouched Photographs of Various Subjects as they Appeared on the Screen of a Baird "Televisor" Receiver

That on the bottom right-hand corner is an ordinary flat magazine cover portrait

that the neon happens to be placed, but the picture will be turned round the farther we progress from its correct position, the case illustrated being that for a 180 degrees phase displacement.

There is the matter of "framing the image," but this

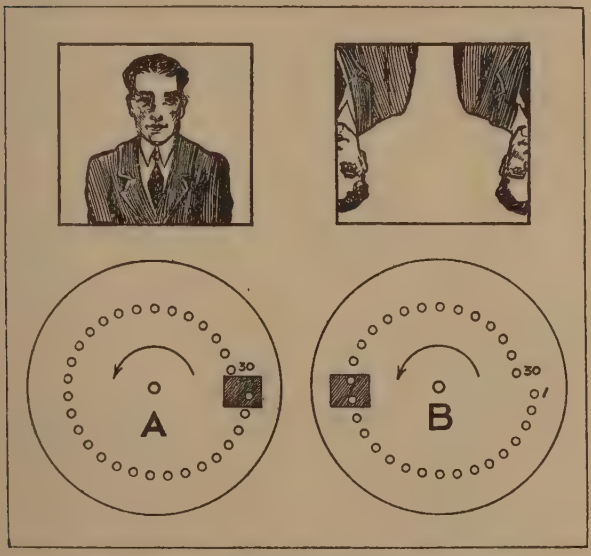


FIG. 9. HOW AN IMAGE APPEARS UNDER CERTAIN EXTREME CONDITIONS

is essentially wrapped up in the question of synchronizing, and, therefore, will be dealt with fully in the next chapter.

An examination of some of the accompanying illustrations indicates various models of the "televisor" which have been demonstrated by the Baird Co., but in operating principle they are identical, so that it is unnecessary to deal with each one separately.

A Wealth of Detail Revealed

Some doubt would appear to exist as to whether the detail of the picture, as seen on the "televisor" screen, has improved, and the best way to answer this is to ask the reader to refer to the illustration (facing page 48) of an untouched photograph of the first image that appeared on the "televisor" screen.

Recognizable, perhaps, but compare it with those representing untouched photographs of the present-day image (see plate facing page 50).

Note the wealth of detail revealed and the half-tones, and yet these latter photographs are the work of amateurs, and make no pretence at being professionally finished products.

The difficulties which beset the photographer taking a subject such as is provided by the image of a scanned neon plate are enormous, and in the cases shown the exposures were of the order of 6 to 8 seconds.

Analyse them carefully, and see if you can detect any "movement" such as would be provided by lack of synchronism—there is none. Of course, the pictures as seen by the naked eye are superior to those obtained with the camera, owing to the persistence of vision, but even so, it must be admitted that remarkably good progress has been made.

CHAPTER V

SYNCHRONISM IN TELEVISION

When Mr. Baird decided, in the latter part of 1929, to disclose his jealously guarded secrets of synchronism the world of amateurs was aghast.

Up to that time it is beyond dispute that Mr. Baird had achieved, by his method of synchronism, a system which gave him a definite lead over those who were working on television abroad, and, after all, *synchronism was the crux of the television problem.*

It has always been one of the outstanding problems, and it was the difficulty of discovering a solution in this direction that prevented television from becoming a commercial reality.

Isochronism but not Synchronism

Some have gone farther and have said that it was perhaps *the* outstanding problem. Nevertheless, let us not overrate its importance to the detriment of television itself. After all, as we shall see in the ensuing chapter, we are enabled, once we understand the principles involved, *to achieve a distinct measure of success even when true synchronism is absent.*

Let us, therefore, first of all get a clear impression of what is meant by synchronism.

Supposing there were two accurate clocks, one situated in London and another in New York, the angular movement of the hands would be identical, but the actual times would be different.

Two wheels of equal diameter on a bicycle will revolve at the same speed, but it is long odds against them being in synchronism.

The condition which these two cases quoted have fulfilled is that of *isochronism*.

The Conditions for Synchronism

The mechanisms are running at the same speed, but there is another condition to fulfil before synchronism is achieved, and that is they must be " in step," or in the same phase relationship.

With the clocks, then, the hands must not only move at the same rate but point to the same time, and with our bicycle the wheels must fulfil the condition that similar spokes in the wheels must be pointing in the same angular direction at the same instant.

Thus we can achieve isochronism without synchronism, but never synchronism without isochronism, and the bearing that this has upon our received television images will be made clearer later in the chapter.

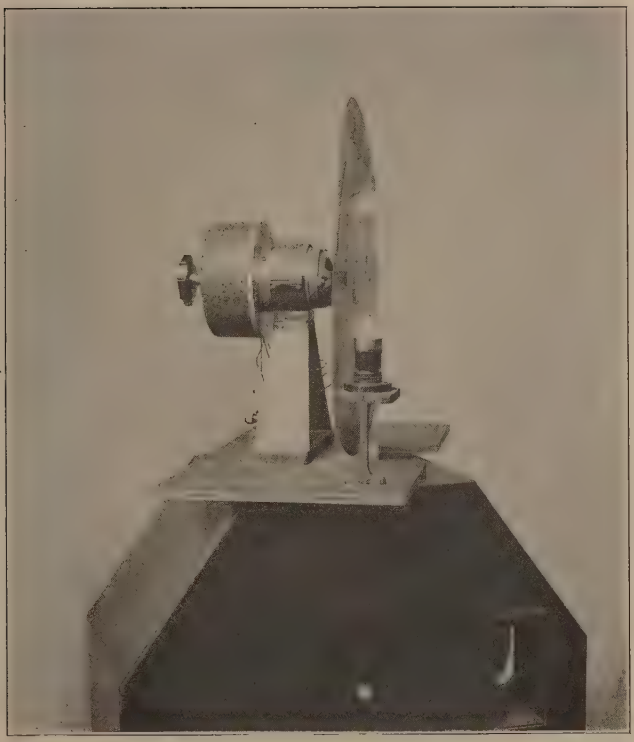
Essentially, the main problem to start with is to ensure isochronism between transmitter and receiver discs, although the two pieces of apparatus may be separated by hundreds of miles. *Unless this is accomplished nothing in the nature of a commercially practical television scheme will be possible.*

Several Devices Suggested

Many and varied have been the methods proposed and put into practical operation, but they have not survived the rigorous conditions of commercialism.

For example, one can call to mind the use of alternating current synchronous motors.

This device gives quite successful results, *but it necessitates the use of a separate channel of communication* for the alternating current driving the two motors, as both motors must be driven from the same source of power.



THIS MODEL "TELEVISOR" WAS ON SHOW AT THE 1929 OLYMPIA RADIO EXHIBITION

The synchronizing mechanism is enclosed in the large end casing

In America use has been made of the alternating current mains. Where the transmitter and receiver motors can be connected to the same supply network, synchronism may be achieved by this means.

It is fairly obvious, however, that only within *very restricted areas* is the same source of alternating current available with any degree of reliability.

In consequence, this does not provide anything approaching a universal solution to the problem.

Another suggestion, also emanating from the U.S.A., is to transmit a synchronizing signal of definite frequency, and tune both the transmitter and the receiver mechanisms to this.

Bristling with Difficulties

But the idea fairly bristles with practical difficulties, quite apart from the fact that another wave-length is required for transmission purposes.

Then we can cite the efforts made to obtain synchronism by means of independent oscillating systems, such as oscillating crystals, tuning forks or oscillating valves, the alternating current generated by these devices being amplified and used to supply synchronous motors.

Such devices are extremely complex and expensive, and are only suitable for operating under laboratory conditions, or where an expert staff is available.

In consequence these are quite impractical for general public use.

Therefore, before television could become commercially practicable for broadcasting to the home, *some form of synchronism had to be invented which would not necessitate the use of separate channels of communication*, and furthermore would be sufficiently simple and inexpensive to come within the scope of the domestic user.

This was accomplished by Mr. Baird, and was shown in operation during the Radio Exhibition at London in September, 1928, and was further publicly shown at the demonstration given in March, 1929, before the Committee of Members of Parliament and Post Office and B.B.C. Engineers.

An Historic Occasion

On this historic occasion television was transmitted through 2LO and received at St. Martin's-Le-Grand, before Lord Clarendon, the Postmaster-General, and engineers and Parliamentary committee, and was received simultaneously at Savoy Hill before Sir John Reith, the Director-General, and other officials of the B.B.C.

On these occasions no separate synchronizing signal was sent out, the picture being transmitted through 2LO, and the speech through the Marconi station on a separate wave-length. The picture itself provided the synchronizing impulses necessary to keep the receiver in step with the transmitter. The means used to accomplish this have only recently been disclosed fully, and are, therefore, exceptionally interesting, and are the result of months of patient investigation on the part of Mr. Baird and his engineers.

Now, is there any component part of our television signal which possesses an unvarying characteristic, or one that varies exactly in accordance with our transmitter disc?

The answer—there is.

The actual strip sequence, which occurs thirty times for every revolution of the 30-hole scanning disc, *is the only part of our television signal which does not depend upon the light, shade, or contour of the subject being televised.*

Using Part of the Picture Signal

Can we, therefore, in any way take from the picture signal part of the current, and use it to keep the receiver mechanism in step with the transmitter mechanism?

There is a signal radiated no fewer than 375 times per second (assuming that 12½ pictures per second are

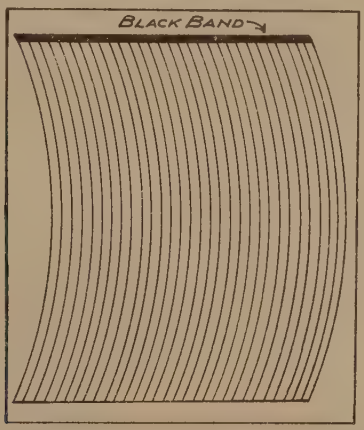


FIG. 10. THE NARROW BLACK BAND WHICH PROVIDES THE SYNCHRONIZING IMPULSE IN THE BAIRD SYSTEM

being transmitted). This signal has a *very well-defined beginning and ending*, with a definite intervening period.

And it is this fundamental component which we press into service.

If you observe a televised picture in a Baird "televisor" receiver, you will notice a thin black horizontal band at the top marking the boundary between one picture and the next.

This is shown diagrammatically in Fig. 10, and the depth of the band is approximately equal to one hole of the scanning disc.

It is artificially introduced by means of the "gate"

we mentioned in Chapter III, the depth between the two movable portions being carefully adjusted for this specific purpose.

Introducing the Black Band

Actually it means that for a very minute fraction of a second *there is at the top of the spot light sweep no*

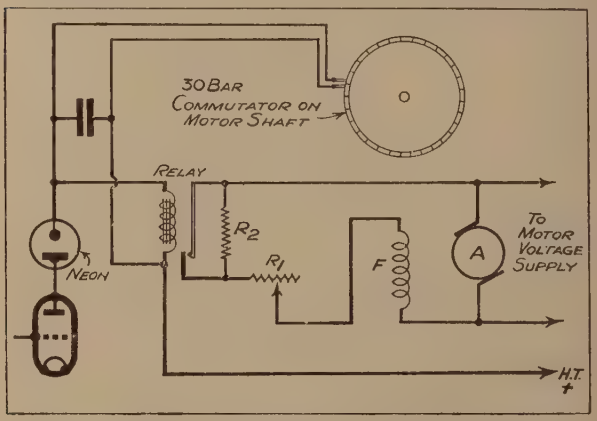


Fig. 11. The Salient Details of the Baird Relay Synchronizing System Shown in Diagrammatic Form

illumination, either on the televised subject or on the white back screen, and thus no current flow in the photo-electric cell circuit.

It constitutes a definite signal depending absolutely on the transmitter mechanism, and if we can make our receiver in some way respond to this, *isochronism is assured.*

Until quite recently, what is known as the relay synchronizing system functioned from this signal, and although this method has now been definitely abandoned in favour of a simpler but more effective device, the ingenuity of the arrangement warrants mention in this book.

The Mechanism and Controls in the Baird Relay System of Automatic Synchronizing

Fig. 11 gives the salient details of the apparatus. It depends for its successful action upon the control of motor speed by cutting out part of the motor field resistance as occasion demands.

If the circuit is traced out, it will be seen that there is a variable resistance R_1 and a fixed resistance R_2 in series with the shunt motor field.

Relay Synchronizing

Across this fixed resistance, however, we have the contacts of a small relay, so that when current passes through the energizing coil of the relay the contacts close and the fixed resistance is "shorted out."

This would increase the motor field current and reduce the motor speed.

The output plate current from the last valve, or valves, of the wireless receiver passes through the neon of the "televisor," and thence to H.T. + via the path provided by the energizing coil of the relay.

Note, however, that this relay coil has across its ends two leads, which pass to two phosphor-bronze brushes slightly staggered with reference to each other, and bearing on a 30-bar commutator, which is attached to that end of the "televisor" motor shaft remote from the disc.

Consider now the action.

The commutator with its 30 bars, corresponding to the 30 holes in the disc, is so positioned on the shaft that, during the period that current is flowing in the neon circuit, as a result of cell activation at the transmitting end while the light spot is travelling up the unshaded strip area of Fig. 10, *the relay coil is short-circuited owing to the two brushes bearing on the same bar of the commutator.*

During this time, therefore, the relay arm is not

pulled over, and the fixed resistance R_2 remains in series with R_1 and the motor field winding.

Working Details

At the same instant that a change-over is effected on the commutator (so that one brush is bearing on one bar and the other brush is bearing on the next bar), *signal current ceases to flow in the plate circuit*, because we have reached the scan of our masked picture strip, that is, the top shaded portion of Fig. 10.

Thus, although the short circuit is removed from the relay coil, *it does not function owing to this cessation*, momentary, of course, of the signal current.

If, therefore, the "televisor" motor had originally been run up to the speed of the disc at the transmitting end, by adjusting the variable resistance R_1 (actually this is a panel control), and the two motors are in step, the relay arm is not pulled over and *isochronism is established.*

Now, what will happen if the "televisor" motor through some agency, say a slight variation of supply voltage, experiences a small increase in torque, and thus tends to run faster than the transmitter motor?

While the brushes of the relay mechanism are "shorted" nothing can happen. At the transition period, however, when each brush bears on a separate commutator bar, the scanning at the transmitting end, since it lags on the receiving end, has not reached the top black section of our scanning area.

Changes in Motor Torque

Signal current is still flowing in the neon circuit, therefore, and our relay contact closes because the commutator and brush short is removed. The closing of the relay short circuits the fixed resistance R_2, field

The Arrangement of the Cogwheel and Pole-pieces is Clearly Seen in this Photograph

current in the motor circuit increases, and the motor slows down slightly.

If the " televisor " motor happens to experience a slight drop in torque, then the relay action, which in effect acts as an electrical brake, tends to make matters worse, although normal running speed is frequently restored after the " televisor " motor has slipped an amount equivalent to one or two holes in the receiver disc. Although this most ingenious Baird relay synchronizer provided the necessary control for the bulk of the demonstrations and work up to the advent of the improved method, it will be seen to possess several drawbacks of a very practical nature.

Practical Drawbacks

First of all, consider the number of changes which have to be effected during that very small interval of time when the brush short circuit is removed, and the relay is brought into action. Current has to be built up in an inductive coil, that is, the relay coil, the relay arm pulled over, and the resistance R_2 " shorted out." Current now has to rise in another inductive circuit, the field circuit of the motor, and a corresponding decrease of speed registered owing to this larger field current. Once the relay arm is released normal conditions have to be re-established. This continual braking of the motor produced rather a bad " picture hunt," that is, the received picture had an unpleasant habit of rising and falling about a mean position in a sort of rhythm corresponding to the correcting impulses given to the motor.

Not only that, but the relay needed constant attention, and had to be adjusted and set up at frequent intervals, the contacts required cleaning and adjusting, and the brushes caused uneven wear on the commutator

owing to their staggered arrangement, which resulted in sparking, and affected the picture.

A Better Method

Generally it was found best to adjust the value of the variable resistance R_1, so that the "televisor" motor tended to run slightly faster than the transmitter motor, and, as was mentioned earlier, in spite of its apparent defects, it constituted the only form of automatic television synchronizing which stood the test of wireless demonstrations under stringent conditions.

As a result of intensive investigation into this synchronizing problem, the Baird Co. have evolved a far more effective method of "holding the picture steady," and yet its construction is very much simpler.

It is called the MAGNETIC TOOTHED WHEEL SYNCHRONIZER, and takes the form of two small electro magnets, so mounted on a metal frame-work that they are diametrically opposite to one another. This frame-work, in turn, is mounted on the front of the "televisor" motor, so that a mild steel wheel having 30 evenly spaced teeth cut in its periphery, and mounted on the motor shaft, can rotate between the poles. The shape and facet area of both the poles and teeth are identical, and only a very minute clearance is allowed between teeth and poles as the wheel rotates.

Two Special Magnet Coils Required

The cogged wheel is definitely different in action and construction from the well-known "phonic wheel," which is merely a simple form of synchronous motor. The teeth of a phonic wheel are equal in width to the gaps, and it must be driven by current of approximately sine wave form. The cogged wheel has teeth very narrow in comparison with the spaces, and is a

purely correcting device, operated by the very brief impulse given by the line at the top of the picture. It is essentially similar in principle to the relay synchronizer. This is important, as a phonic wheel operated from the picture will not be successful.

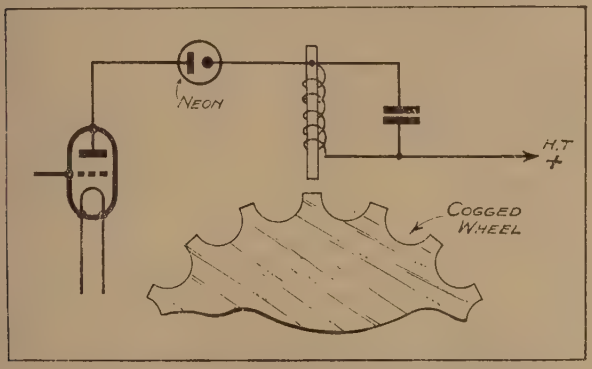


FIG. 12. THE ARRANGEMENT OF THE LATEST BAIRD MAGNETIC TOOTHED WHEEL SYNCHRONIZER, WHICH IS AUTOMATIC IN ACTION

The relative positioning of the cogged wheel, with reference to the pole pieces, is such that a tooth facet and pole face are exactly opposite to one another (see Fig. 13) when the scanning hole is just cut in halves by the bottom edge of the black band shown in Fig. 10.

Analysing the Action

Examining the action a little more carefully, we see that as the teeth *b* and *y* of Fig. 13 are approaching the poles, which are made of north and south polarity by the signal current flow, they are attracted, and, in consequence, there is an accelerating action, and at the moment teeth *b* and *y* are half their facet width past these poles the maximum accelerating force has been reached. This point corresponds to the instant when

the scanning operation is just wholly on the black band of our scanning area shown in Fig. 10.

When past this point, and signal current again flows through the poles, there will be a retarding force on teeth *b* and *y*, but when treated as a whole, however,

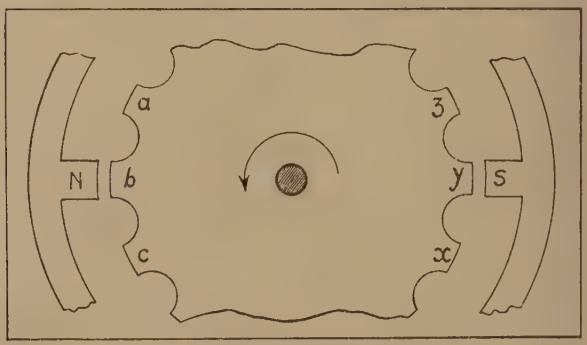


FIG. 13. HOW THE COGGED WHEEL SYNCHRONIZER WORKS

and bearing in mind the effects produced on each tooth in turn, then the wheel, and in consequence the "televisor" disc, exhibit a marked tendency to be held in step with the transmitter motor, retarding and accelerating forces cancelling out for each cycle of changes.

A Retarding Impulse

Supposing the "televisor" motor does tend to run a little faster, what will happen? Why, instead of the period of no signal current occurring at the point where teeth and poles are leaving, it will occur when they have passed. But once the teeth start to pass the poles there is a magnetic attraction tending to pull them back, whereas at synchronous speed this retarding impulse occurred later in the cycle of changes. With the teeth

endeavouring to run ahead, therefore, the retarding impulse predominates, and the wheel gives way to the braking action and drops to its normal speed.

Short of an actual demonstration, it is difficult to realize the holding force of this latest form of Baird synchronizer. The picture remains steady for extremely long periods, the previous " hunt " or " swing " being conspicuous by its absence. Should the motor tend to retard its speed an amount sufficient to " slip a tooth," the accelerating impulse after this one tooth has slipped will again predominate, and pull it into the isochronous speed.

Proof of the Efficiency

The system, therefore, bids fair to remain the standard for some time to come, and has many advantages to recommend it, amongst which may be mentioned cheapness, ease of manipulation, simplicity, absence of an impedance being constantly inserted in series with the neon circuit as was the case with the relay synchronizer, and absence of " wearing parts."

As proof of its steady picture holding, one has only to examine the photographs of televised subjects shown in the plate facing page 50. The exposure was of the order of 6 to 8 seconds, and although the photographs are untouched, it is almost impossible to detect any " movement " of the subject.

Now let us clear the air a little as to what would happen if perfect synchronization was not present in our televised picture. Unfortunately, a number of wrong impressions have got abroad as to the principles involved, and, strange to say, these frequently have been shared in prominent technical circles. Enough has been said in preceding paragraphs to indicate that if the *speeds* of the transmitter and " televisor " disc

are different, the picture instead of having a rectangular outline, will appear to be diamond shaped and all the details twisted. Of course, if the difference in speeds is very high, then the whole image will dissolve into a blur of moving spots.

Removing a Misunderstanding

To be strict in definition, both the relay and cogged wheel systems just described are used to promote isochronism, that is, give a perfectly steady picture of rectangular outline. As we have seen in Chapter IV, however, isochronism can be established, and yet the picture may be "split" about a vertical dividing line. This is really a difference of *phase*, and some critics have gone so far as to say that a small difference of phase is sufficient to spoil the definition of the received image. Obviously, this statement is ridiculous, for a difference of phase in the synchronizing mechanism does not affect definition, but merely causes a displacement of the image to right or to left. This is rectified by altering slightly the speed of the "televisor" motor, either electrically or mechanically, so that it "slips" the requisite number of holes to bring the picture to normal positioning. Once this has been done, the knack is soon acquired; *we have the conditions of both phase and isochronism established, and we can then say truly that both mechanisms are in synchronism.*

Framing the Image

There is another effect which has to be provided for, and that is "framing the image." No doubt most people can recall having seen pictures on the cinematograph screen, where the actor's feet are at the top of the screen and the head at the bottom. The picture has not been framed properly, and in the picture seen

in the " televisor " screen this sometimes happens, and we view, say, a woman's head and shoulders split horizontally somewhat as depicted in Fig. 14. To rectify matters in the case of the cogged wheel synchronizer, a knob is provided at the front of the " televisor," and on turning this in either direction as desired, the

FIG. 14. A PICTURE INCORRECTLY " FRAMED " GIVES THIS APPEARANCE ON THE SCREEN

whole carcass of the driving motor is rotated bodily in a special mounting, and this will reset the picture.

With the older type of synchronizing, that is the relay method, a little rack and pinion was operated from the front of the " televisor " by means of a small knob, and this bodily moved the two staggered brushes round the commutator a small distance, and the picture moved up or down on its screen until it was accurately framed within the mask provided

The importance of *automatic synchronizing* cannot be over-emphasized, and of all television systems throughout the world that evolved by Mr. Baird and his engineers is the *only* automatic one of universal application which has worked satisfactorily.

CHAPTER VI

PHOTO-ELECTRIC CELLS AND NEONS

In earlier chapters we have made the formal acquaintance of both photo-electric cells and neons, and while it is not intended in any way to go at all deeply into these two important links in our television chain, it is felt that the reader would welcome the opportunity of gaining a little further knowledge of their prime functions.

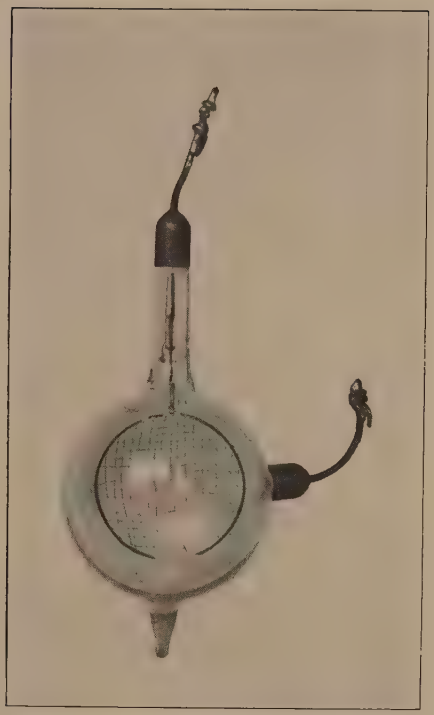
Let us deal with the "eye of television" first, for within the last few years the photo-electric cell has come to be recognized as one of the most important of modern scientific devices. Until its advent television seemed becalmed, but when its properties were thoroughly appreciated its superiority over sluggish selenium made television a practical proposition instead of a scientific toy.

The Photo-electric Cell's Real Purpose

Stated simply, its prime function is to convert light variations into current variations, and some of the best types of cells for this purpose are those manufactured by the G.E.C. Some idea of their appearance can be gained from the accompanying photographs, and it must be borne in mind that actually we have both vacuum and gas-filled cells.

In a vacuum cell the size and the form of the bulb and electrodes have no effect upon the current obtained with a given amount of light incident on the cathode; but, of course, if the cell should be exposed to diffused light, the larger cathode will give the greater current because it receives more light.

A cell in which the cathode is not part of the wall of



A Standard Form of G.E.C. Photo-electric Cell

the bulb is more regular in action, it being remembered that with the vacuum cell the current is that carried by the electrons directly liberated from the cathode by the light. This type of cell is preferable in everything but sensitivity, and the emission varies very greatly both with the material used for the cathode and with the quality of the light.

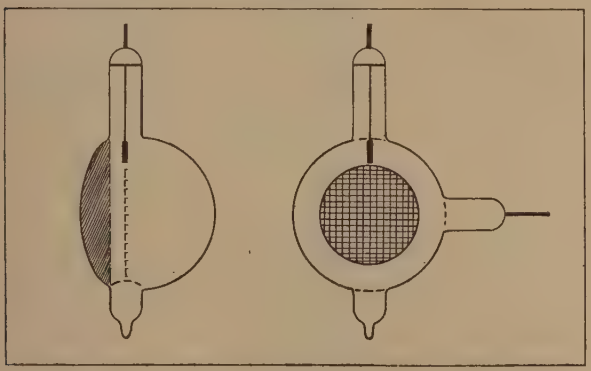


FIG. 15. DETAILS OF THE STANDARD OSRAM PHOTO-ELECTRIC CELL

Sensitivity of Prime Importance

The light sensitive metal used for the cathode may be potassium, sodium, rubidium, or caesium. For television purposes where sensitivity is of prime importance, owing to the very small amount of light reflected from the televised object, gas-filled cells are to be preferred. In these the primary current is magnified by the production of secondary electrons when the primary electrons travel through the gas.

Furthermore, the size and form of this type of cell may make a considerable difference to the magnification of the primary current by the gas-filling. The standard Osram photo cell has a cathode of potassium sensitized

by a discharge in hydrogen, and is filled with argon. The cathode is a layer deposited on the silver coating on the bottom of the cell, while the anode is a ring, covered with gauze, parallel to it, and Fig. 15 shows the shape and appearance of this particular type.

Magnifying the Current

The purpose of the argon filling is to magnify the primary photo-electric current, which consists of a stream of electrons emitted from the cathode when light falls on it. These electrons travel through the gas under the attraction of the positive potential, which must be applied to the anode, ionize the molecules of the gas, and set free other electrons which are added to the primary stream. The amount of this magnification depends greatly upon the voltage applied between cathode and anode, and a careful consideration of this is, therefore, necessary before actually putting the cell into commission. Since, however, this is essentially a matter for the transmitting side of the television system, a dissertation on the characteristics, precautions to adopt, "flashing," etc., would only be out of place in these pages.

What must be mentioned, however, is the fact that the cell has to be connected to an amplifier to obtain normal working outputs, for although the current through the cell increases when the light incident on the cathode is increased, the current obtained with such light as is usually available does not exceed a few hundredths of a micro-ampere, and is often much less.

Amplification Necessary

In the application of photo-electric cells to television, there are light variations occurring at frequencies up to at least 20,000 per second, and these have to be

Some Photo-electric Cells are Particularly Sensitive to Infra Red Rays, and the above Illustration Shows One Type

translated into corresponding variations of amplified current. The problem, therefore, resembles very closely that of audio-frequency amplification, with the proviso

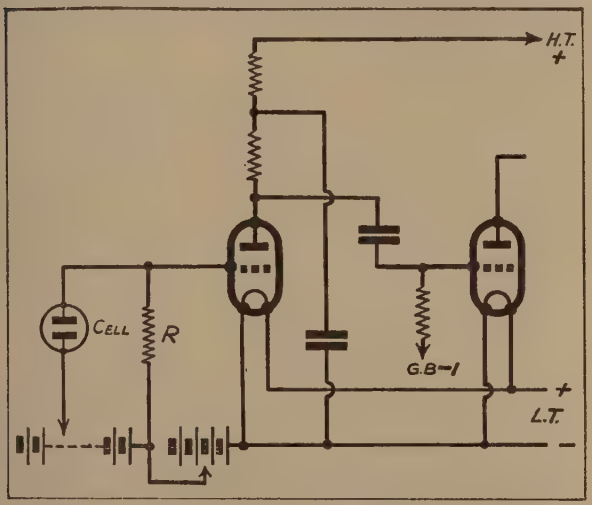


FIG. 16. ONE WAY OF CONNECTING UP THE PHOTO-ELECTRIC CELL TO ITS AMPLIFIER

that frequencies outside the audible range must be catered for in the amplifier.

This calls for a multi-stage resistance capacity amplifier, with special methods adopted for handling the higher frequencies. The number of stages in the amplifier must be settled by the degree of overall amplification required before the signal pulses are fed to the line, and the Baird Co. have developed a special amplifier which gives a remarkably even amplification for all frequencies within the range desired.

Connecting the Cell in Circuit

The resistance *R*, shown in Fig. 16, which gives one form of coupling, requires special consideration, for the

greater its value the greater will be the variation of the grid potential of the first valve produced by a given photo-electric current, and the greater, therefore, the sensitivity. A limit is set, however, by distortion at the higher frequencies. Capacity effects are likely to prove troublesome, and the cell should be mounted as close to the grid of the first valve as conveniently possible, so that lead capacity is at a minimum.

As far as can be measured with modern instruments, there is no time lag in the primary photo-electric current response to a light pulse. Anything in the nature of an apparent lag is traceable generally to the presence of a condenser capacity which the minute photo-electric current takes time to charge, and this has to be guarded against.

How the Neon Lamp Works

Coming now to neon tubes, we are all more or less familiar with those patterns used for advertising purposes in the form of shaped letters, and also the beehive pattern so popular as night lights. At the receiving end we saw the necessity for a form of illumination, which would not only be instantaneous in its response to the current variations produced by the television signal, but would also withstand the rapidity of these fluctuations.

This is supplied by the neon lamp, which, according to the specific television purpose for which it is required, can take several forms. Evidence of this is furnished by the group photograph of neon lamps (facing page 74), all of which at some time or another have been used by the Baird Co. in the course of their investigations.

No attempt will be made to discuss the theory underlying the action of this tube, since it brings in such things as Crookes' dark space, negative glow,

The Position of the Photo-electric Cells is clearly Shown in this Picture of Miss June Collyer being Televised at the Studio of the Baird Television Corporation of America

positive column, Faraday's dark space, ionization, etc. Suffice to say that the lamp is filled with a gas, called neon, generally obtained from the atmosphere, at a very low pressure. This is the same as saying that the number of atoms of neon present inside the glass bulb is relatively small. In order to assure constancy in its normal functioning it is essential that this gas pressure should have a certain exact value in each lamp, so that care and precision are called for in manufacture.

If a certain definite voltage of the order of 160 volts is applied between the electrodes of the lamp, a current is forced through the lamp, and, due to atomic bombardments and ionization, the neon atoms become heated and glow with a reddish orange colour which is the characteristic of the lamp.

Points of Great Importance

There are two points of great importance which should be noticed, the first being that the neon tube possesses no appreciable time lag or inertia, and thus responds instantaneously to the passage of an electric current. This is a remarkable feature when we realize that it has been shown possible to light or extinguish the lamp at the enormous rate of one million times per second. Our next point is that the intensity of the glow is directly proportional to the current strength.

For the normal television purposes, such as we have discussed in earlier chapters, there is one type of neon lamp which meets the case admirably. This is shown in the pair of neon lamps in the centre of the group photograph. The negative electrode is made in the form of a rectangular metal plate (nickel is the metal usually employed for this purpose). This is mounted vertically as shown, and the positive electrode consists of a short metal rod mounted immediately behind and in the

centre of the plate, the two electrodes being separated by a small distance.

Where to Place the Neon

When constructed in this way and the correct striking voltage is applied, the whole of the neon plate glows and a certain current flows through the circuit of which

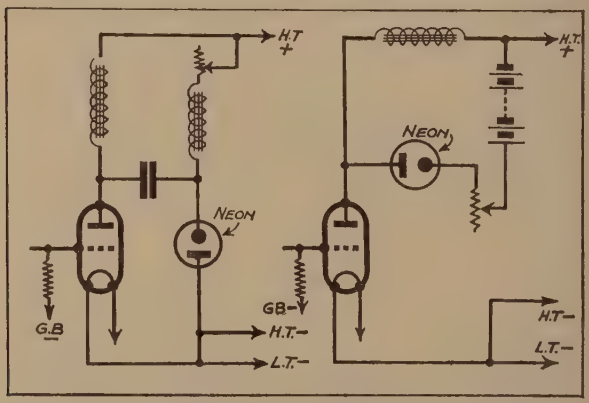
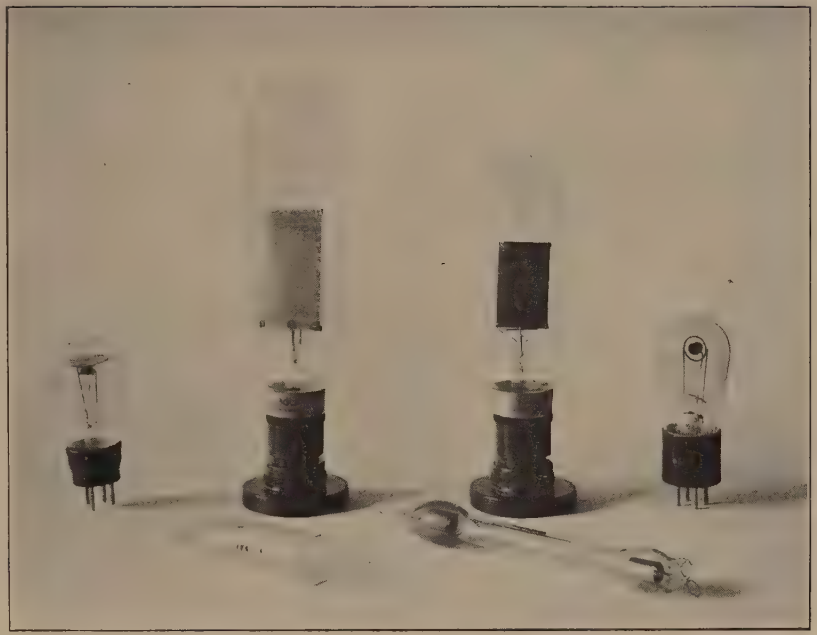


FIG. 17. SIMPLE METHODS FOR JOINING THE NEON LAMP TO THE OUTPUT VALVE OF THE WIRELESS SET RECEIVING TELEVISION SIGNALS

it forms a part. Therefore, if we connect this neon tube in the output circuit of our wireless receiver, and vary the current flow by the television signal pulsations, we have the glow of the lamp varying as the original light pulses from the transmitter. As we have learnt, these rapid light changes are viewed through a scanning disc, and produce the effect of a built-up picture on the rectangular-shaped anode itself.

The smaller type of plate neon illustrated can be operated successfully from an amplifier using no more than 300 volts, and the current is furnished adequately by valves of the LS5 class. This is effected by choke



A Few Representative Types of Neons Used in Television Investigations

coupling the neon, so that it is not directly in series with the plate circuit of the last valve.

One or two methods for carrying this out are shown in Fig. 17, and it is best to arrange a variable resistance in circuit with the neon so that the voltage may be adjusted carefully. Do not have the plate too dark, and bear in mind that the grid biasing voltage to the last valve (or valves if in parallel or push-pull) must be adjusted jointly with the neon voltage, in order to get the most efficient results when the neon is in series with the valve. The higher the biasing voltage for a given electrode voltage, the darker the appearance of the neon plate, and if this is pushed too far dark shadows will appear and spoil the television picture.

CHAPTER VII

THE WIRELESS RECEIVER FOR TELEVISION

We have seen that the use of a wireless receiver is necessary for the reception of television. Comes the question: Which wireless receivers will be suitable for this purpose?

The average wireless listener will ask himself whether his wireless receiver, which has done yeoman service in receiving aural broadcasting, will be equally suitable for the reception of television broadcasting?

Give Your Own Verdict

Obviously, the answer to that question is bound up primarily in the type of receiver which has sufficed so far, and the best interests will be served, therefore, if we take each section of the wireless receiver, that is, high frequency side, detector, and low frequency, and analyse these carefully. Then the reader will be in a position to pronounce his own verdict, it being at once apparent that a poor wireless receiver can only result in poor pictures, more so than in ordinary broadcasting, for while the eye is accommodating in many respects, generally it is more critical than the ear with a normal person.

With both speech and picture being transmitted on separate wave-lengths, it is at once apparent that two receiving sets will be necessary, so that if the reader is already in possession of one set, he is recommended to let the successful reception of television signals be his criterion in purchasing or making the second set, leaving the old set to continue its normal function of serving the ear.

A Baird Dual Receiver Model which Contains Two Receiving Sets, One for Speech and One for Vision

Signal Strength Required

Leaving quality for the moment, and turning to the strength of the received television signals, for, of course, they can be heard as a distinctive note on the loud speaker, perhaps the simplest way of judging the receiver's merits is to say that these signals must be of *good* or *strong* loud speaker strength.

Of course, if you substitute a neon lamp for your loud speaker, you can watch it flickering with relatively small inputs, but if you attempted to resolve this into a picture by scanning it with a perforated disc, the result would be a very faint picture or even no picture at all, and obviously this is not what is wanted. The output power from the set has to operate the neon lamp in a healthy manner, and, even with the smaller type flat plate neon, this power has to be of reasonable dimensions to make it function satisfactorily. The stronger the signals the better the picture up to a point, for if there is too much output the picture will be " cooked," that is, there will be such a brilliant contrast between light and shade that detail is lost. It is the same when we attempt to overload our loud speaker, quality reproduction is then at a discount.

The Best Type of Detector

So much for the first criterion, what is the next point to consider? Preference will be given to the detector stage, and issue must be joined with the protagonists of either grid leak or anode current rectification, since these are the two most popular methods now in use.

As we all know, the detector valve in a wireless set has only high frequency oscillations applied to it, and its purpose is to convert these into a pulsating unidirectional current, which usually is amplified by further stages of low frequency coupled valves. The amount

of modulation of the high frequency carrier is varying throughout the time a broadcast is taking place, but effective measures are adopted to prevent the wave being over-modulated, as this would of itself introduce distortion, and distortion at all costs must be avoided. Our detector valve, therefore, has to deal faithfully

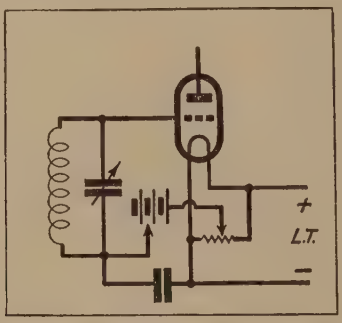


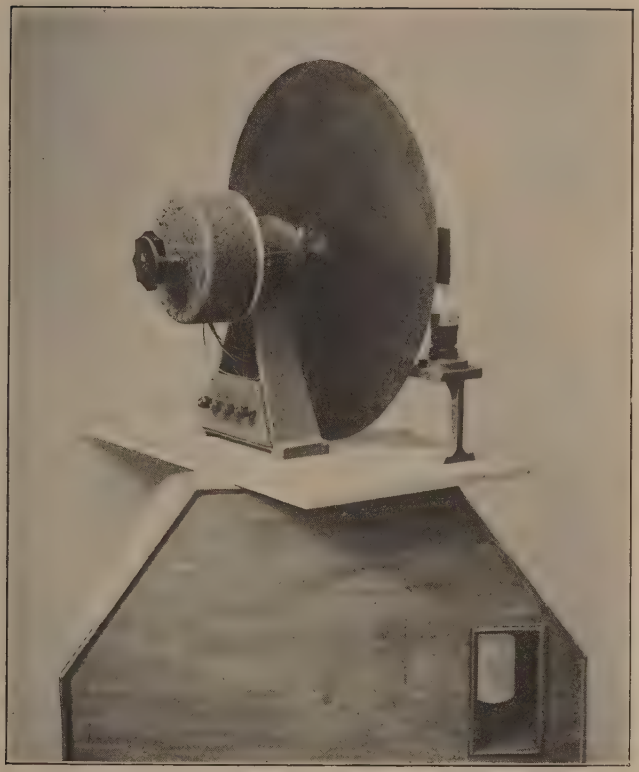
Fig. 18. One Way in which it is Possible to Connect Up a Detector Valve for Anode Bend Rectification

with the signal impressed upon its own grid, and pass on to the grid of the first low frequency valve an output which is a true representation of this signal.

Taking Each Form in Turn

What is the prime difference between the two methods of detection? Apart from circuit details, this can be answered quite simply. In the case of grid leak rectification, the actual process takes place in the grid circuit of the valve and the resulting low frequency currents undergo magnification in the valve itself, whereas with the anode bend arrangement the reverse holds, that is, the high frequency currents are amplified in the valve first and are then rectified in the plate or anode circuit.

Let us deal with each system in turn, taking anode bend rectification first.



One Form of Baird "Televisor" which was Used for Coupling to the Wireless Receiver

We use the bottom bend of the anode current grid voltage characteristic to effect the actual rectification, and, in consequence, sufficient negative grid bias must be applied to work at the proper point, the exact value, of course, being contingent upon the plate volts fed to the valve. A reference to Fig. 18 will give one quite

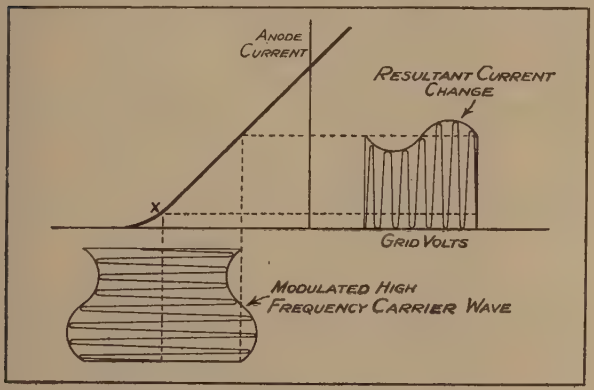


Fig. 19. Diagrammatically Illustrating how Rectification Takes Place in a Valve Working on the Anode Bend Principle

satisfactory method of connecting up the valve for this type of rectification, the potentiometer across the low tension supply giving the fine control of the biasing voltage.

Maintaining Proportionality

To illustrate simply how rectification actually takes place, turn to Fig. 19. Assuming a modulated high frequency carrier wave is applied to the grid, which has been biased to the point marked X, then the resultant plate current change due to the modulation (and, after all, this is in effect our electrically disembodied picture) takes place on the straight part of the characteristic. There is then absolute proportionality between input

and output signals; the only difference lies in increased strength due to valve amplification, and, in consequence, we have no distortion. Note that the impression of the signal has caused an *increase* in mean anode current. Should the modulation be too strong with the particular setting chosen, or if the plate and grid voltages are too

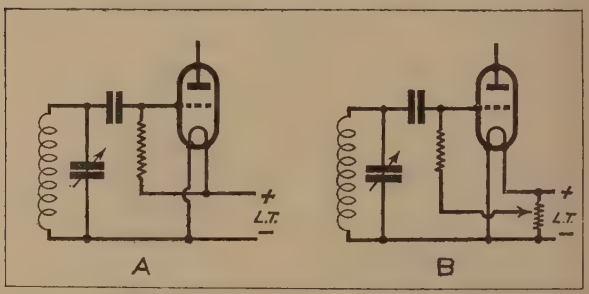


FIG. 20. TWO METHODS FOR JOINING UP A VALVE TO WORK AS A GRID LEAK RECTIFIER

low, then it will be quite obvious that the voltage swing on the grid will run on to the positive side of the characteristic, and grid current flows with resultant distortion, for the condition of proportionality is lost when this happens.

On the other hand, we can see from the diagram that if signals should happen to be weak, then the curved portion of the characteristic is brought into use and distortion occurs again, since there are not proportional plate current changes to grid voltage changes.

Now what of the other form of rectification?

Grid Leak Rectification

A fixed condenser of about ·0002 to ·0003 mfd. is inserted in circuit, as shown in Fig. 20A, to offer a high impedance to the low frequency modulation of the

A Form of Table Set Complete with a Large "Televisor" which Houses both the Loud Speaker and Television Apparatus

carrier wave, while the valve grid itself is connected through a resistance of about two megohms to L.T. + so that grid current flows. When the high frequency signals are impressed through the tuned circuit, oscillations pass to the grid through the small grid condenser, but owing to the high impedance of the grid leak and to the varying grid current produced by the signal, the grid voltage varies in accordance with the low frequency portion of the signal. Actually, the grid condenser when working collects changes of electricity which reduce the normal grid voltage, and, of course, the anode current *reduces* in sympathy, as will be seen if a milli-ammeter is joined in the plate circuit of that valve.

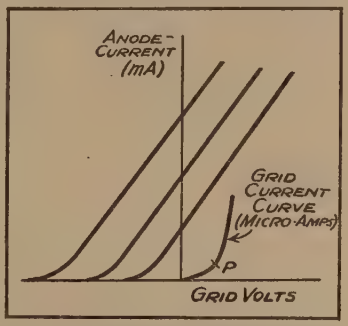


FIG. 21. THE BEST POINT TO WORK FOR GRID LEAK RECTIFICATION IS SHOWN AT POINT *P*

On the grid side adjustments must be such that grid current can flow, but in addition the plate voltage must be so determined that the valve works on the straight part of its plate current grid voltage characteristic. Furthermore, excursions must not be made into the curved portions of the characteristic, otherwise a secondary rectification (actually anode bend) will take place, and distortion occurs. Since it is frequently advantageous to adjust critically the grid voltage, the provision of a potentiometer as in Fig. 20B is useful. Arrange the value of the grid leak and grid voltage so that the grid is working on the most sharply curved portion of the grid current grid voltage curve (see point *P* of Fig. 21).

Possible Distortion

Should a strong signal be impressed upon the grid, the grid circuit is liable to choke, and distortion will accrue, but with relatively weak signals the system is very sensitive and is productive of good results, as we all know from our own wireless sets.

Another point worthy of mention is that since a condenser is present in the grid, there is likely to be frequency distortion, for with increase of frequency the impedance of the condenser falls off. Since previous chapters have emphasized that it is the higher frequencies which add to the wealth of detail in our televised picture, it is as well to note that improvements can sometimes be effected by lowering the capacity value of the grid condenser or grid leak resistance, or by readjusting both plate and grid voltages.

Having assimilated the brief fundamentals of the two methods of rectification, which is best suited to our television requirements? A reference to Fig. 19 will show that the peak value of the modulating signal with anode bend rectification may be as much as twice the normal value of the carrier wave, but in order not to overstep the mark and prevent the flow of grid current, which in this system would introduce distortion, it is advisable to either have some means of regulating the strength of the signal applied to the detector or, alternatively, use sufficiently large values of high tension and grid bias that grid current does not flow. With strong signals grid leak rectification causes distortion, and, in consequence, is only efficient with a relatively weak input. On the other hand, the reverse is the case with anode bend, and the input must be so large that with normal values of modulation only the straight part of the characteristic is used.

Another Point of View

Before coming to a definite conclusion on these controversial matters, let us approach the question from another angle. How are we going to make the absence of distortion compatible with an adequacy of signal strength, which, as we saw earlier in the chapter, is essential, and yet keep the number of valve stages in our receiver within economical limits?

If you are close to the station transmitting the television signals, then the actual voltage induced direct in the aerial will give the strength required for working a detector valve direct, but what of the majority of situations which are generally more distant? Either high frequency amplification must be used or some form of reaction control incorporated. But we know from the experience gained with aural reception that reaction is a notorious agent for introducing distortion, so the best solution would appear to lie in the use of high frequency amplification and a reduction of reaction control to the barest minimum, or, better still, do away with it altogether.

Seeking the Best

Up-to-date practice has proved that one stage of screened grid high frequency amplification brings in all the stations really worth hearing, and consequently worth seeing if they are broadcasting television. This means that a strong signal input will be applied to the grid, and we must, therefore, employ anode bend detection if the best, that is distortionless, output is desired. Of course, this reasoning does not rule out the use of grid leak rectifiers, but since we are seeking the best let us rely on methods which, for our specific purpose, lend the greatest aid.

Useful Operating Details

Now just a brief résumé of the main points to be borne in mind when using anode bend detection, as this will no doubt render assistance to the operator.

Use a valve of moderate impedance and amplification factor.

Follow this with a stage of resistance capacity coupling.

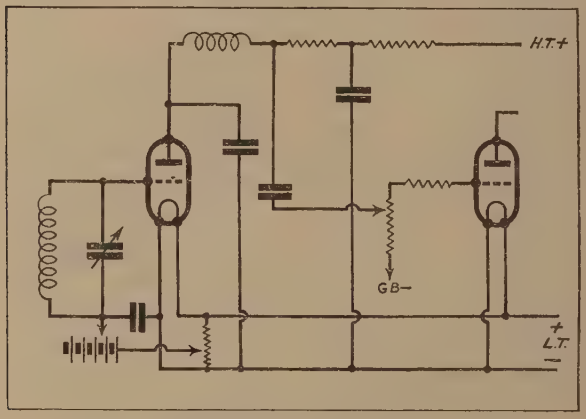


Fig. 22. Useful Refinements in an Anode Bend Detector Valve Circuit

Remember that by increasing both the plate and grid volts within the rated limits of the valve, it is possible to deal with high frequency inputs of any magnitude, sufficient to obtain, with the minimum of low frequency stages, an output which is capable of operating the neon satisfactorily.

Although its inclusion gives a tendency to cut off some of the higher frequencies, it is generally advisable to *insert a by-pass condenser* between plate and filament (see Fig. 22).

A semi-variable condenser of ·0003 mfd. to ·001 mfd.

Miss June Collyer About to be Televised

will be found suitable, then adjustments may be made under working conditions.

Other refinements are as indicated in Fig. 22.

Include an H.F. choke, a decoupling arrangement, a volume control by using a high resistance potentiometer as the grid leak for the first L.F. valve, a " stopper " resistance of about 100,000 to 250,000 ohms

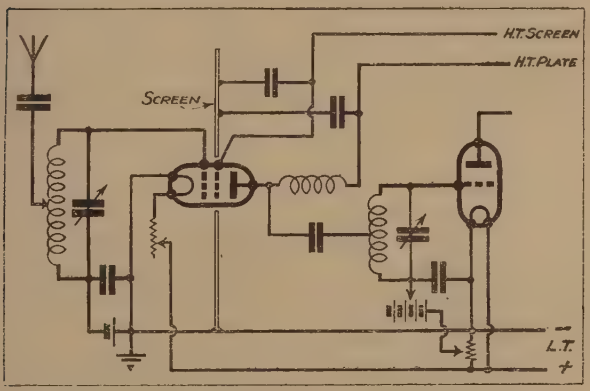


FIG. 23. A SUGGESTED ARRANGEMENT CAPABLE OF GIVING GOOD RESULTS FOR THE HIGH FREQUENCY SIDE OF THE RECEIVER

between the grid and coupling condenser of this same L.F. valve, and, of course, the voltage gradation potentiometer of about 400 ohms to ensure correct biasing to the detector valve grid.

Considering the H.F. Side

Turning for a moment to the high frequency side of the set, *do not have the tuning circuits too sharp,* otherwise this will cut off the higher frequencies.

As to the method of coupling between the screened grid and detector valves, many ways are open to the

choice of the reader. *That illustrated in Fig. 23 has proved to be extremely good in practice.*

See that the two tuned circuits are *adequately screened from one another*, using, say, a "step" screen if the H.F. valve is mounted vertically, or a plain cross screen with a hole to accommodate the valve if the latter is held horizontally.

Naturally, if the set is to be used for "distant" reception, the coils should be of the highest efficiency, and those made of Litz wire will be best suited.

The rheostat in the filament lead of the H.F. valve serves as an admirable volume control for use when required.

We come now to the low frequency side.

A Basic Principle

Let us take for our basis the fact that *distortion is avoided if the increased signal from the output stage differs from the original only in being greater in magnitude*, that is, the output current in the plate circuit of each valve must be directly proportional to the input grid voltage.

To ensure this important detail, the total input volts grid swing to each valve must operate well within that part of the straight characteristic situated on the negative side of the "curve."

By following this principle, it will also prevent the grid from assuming a positive charge.

This factor must be rigidly guarded against, and calls for a careful study of each valve's characteristics, so that adequate plate voltages are applied to the anode of the valve, together with the appropriate grid bias —neither too much nor too little.

Note that the H.T. voltages applied to the set itself *do not represent* the true-plate voltages.

There is always some form of impedance present in

the plate circuit, and this will account for a certain voltage drop, small in the case of inductive impedances but large *when using resistance capacity coupling.*

The actual anode voltages differ, therefore, from that applied to the set terminals.

In choosing the correct negative grid bias, it is the true-plate voltages which must be worked upon, and *not* the battery voltage.

To ascertain what these anode changes are, it is a good proposition to purchase a reliable high resistance voltmeter.

Using Transformers

It is generally accepted that if an amplifier can be made which *does not deviate more than* 10 *per cent from the ideal,* the ideal being one in which every frequency is amplified to the same extent, then the acutest ear or the sharpest eye would be unable to detect any difference.

If an iron-cored transformer is used in the valve plate circuit, we are faced with the fact that theoretically the impedance changes with every change of frequency.

Furthermore, the magnitude of the impedance is dependent upon the mean plate current flowing through the valve. Can we, therefore, expect to approach straight line amplification?

For frequencies up to about 9,000, fortunately, the answer is in the affirmative. This is due to the fact that our low frequency transformer is not quite such a simple instrument as one at first imagines.

One of the main features in the design of this transformer is to *keep the impedance of the primary as high as possible* at low frequencies consistent with small self-capacity at the high frequencies.

By careful design, and bearing in mind that in addition to the inductance of the primary and secondary

windings we have present a leakage inductance, primary and secondary resistance, and primary and secondary winding self capacities, it is possible to produce a component which gives a reasonably steady amplification value up to the frequency limit mentioned earlier.

Avoid Cheap Components

Obviously, a cheap transformer cannot be designed to approach this degree of accuracy, and hence distortion takes place, so to avoid any trouble in this direction choose a reputable make, and use push-pull amplification in the last stage.

To achieve the best results in low frequency amplifiers for television work, however, where the frequency range to be covered for amplification exceeds that of the audible frequency range, *it is found that resistance capacity coupling meets the case in a really excellent manner.*

To avoid distortion here, it is necessary to note that the real secret of success lies primarily in the selection of suitable valves and component values.

Above all, *use valves in each coupled stage which are fully capable of dealing with the relatively large power inputs to their grids without any suggestion of overloading.*

Those falling in the LS5 class are admirably adapted for this purpose.

Amplifier Details

Make the coupling condenser of high capacity value; up to ·1 mfd. is satisfactory, but, of course, in this connection it must be borne in mind that the anode resistance, coupling condenser, and grid leak are all inter-related.

At least, have the first low frequency stage following the detector valve resistance capacity coupled, and,

since three normal L.F. stages are sufficient for securing the power to operate the neon, *endeavour to make the second stage resistance coupled*, with the last stage either push-pull or two large power valves in parallel.

To give some idea of the type of amplifier which has given good results, reference can be made to Fig. 24.

The last two valves are here shown in push-pull, the neon lamp itself being isolated from the actual plate circuits of the push-pull valves.

With a 300-volt H.T. supply, this amplifier will work admirably, and, where possible, the high tension voltage should be derived from a mains eliminator of good make.

Needless to add, the actual design is capable of many variations, and if desired resistance coupling can be used throughout.

The Output to the Neon Lamp

In order to economize on the H.T. voltage side, however, it is *recommended that the neon lamp be fed through some form of efficient filter circuit.*

The question of neon lamps was discussed fairly fully in Chapter VI, but in connection with the receiving set there is a point which must be mentioned.

Provided the output valve, or combinations of valves, is such that *they possess a "grid swing" of between* 30 *and* 40 *volts*, satisfactory results may be assured.

The bias on this last stage should be so arranged that *the neon lamp glows whether the receiving set is tuned to the incoming television signal or not.*

Then, when actually in tune, the signal will cause the current passing through the lamp to alter proportionately to its variations, i.e. a strong variation heightening the brilliance, and a weak variation dimming it.

It is advisable to see that the output impedance does not exceed 2,000 *ohms.*

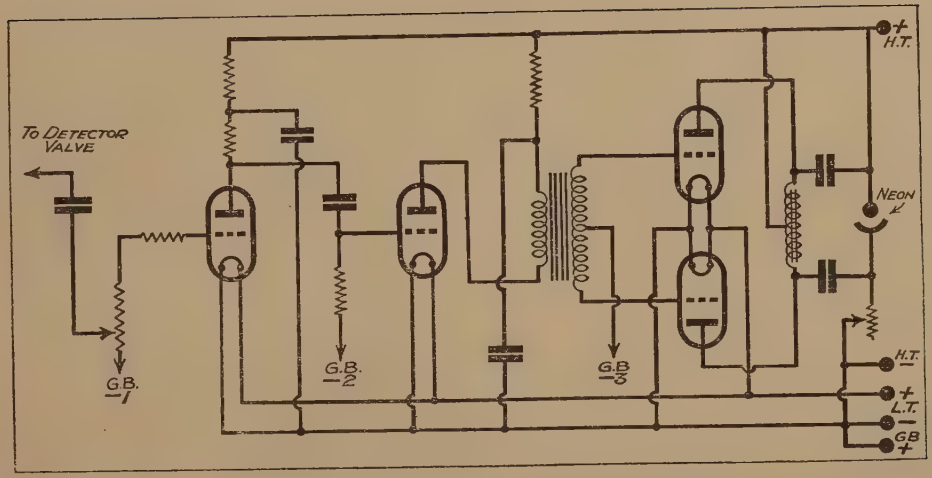


Fig. 24. A Successful Low Frequency Amplifier

Another factor which may appropriately be dealt with here is that arising out of " negative images."

A Negative Image

Anyone who has compared a photographic plate or film with the print made from it, will know what is meant by the relationship between positive and negative pictures.

If you hold the plate up to the light you will notice that all the dark patches seen on the print are light on the negative, and vice versa.

That is elementary. Imagine the confusion that may arise if your received picture, say of a man's head and shoulders, appeared as a negative! What steps can be taken to rectify this puzzling feature, and how is it brought about?

Perhaps you have overlooked the fact that if you have a receiver in which the first low frequency stage is resistance capacity coupled, and the second stage transformer coupled, the signal on the plate of the detector valve is then in the opposite direction from that on the plate of the output valve at the same instant.

Should both stages be transformer coupled, however, the *signal is in the same direction.*

Correct Signal Direction Necessary

This reversal of signal direction through successive low frequency stages may not have any effect as far as aural reproduction is concerned. But when looking at a televised picture the signal direction must obviously be correct.

Again, we have seen earlier in this chapter that in the detector stage, grid leak rectification causes a drop in the mean anode current on receiving the signals; whereas *anode bend causes an increase.*

Thus we have two possible signal directions, according to the type of rectifier in use, so that if one gives a positive picture the other must perforce produce a negative.

Under normal transmitting conditions a positive picture is assured with an anode bend detector, followed by three stages of resistance capacity low frequency coupling.

If grid leak detection is substituted, then it will be necessary at the receiving end to add or subtract one R.C. stage to rectify matters.

If a transformer is included on the low frequency side, then the change from positive to negative is brought about simply by reversing either the primary or secondary connections, *but not both.*

Should the reader, therefore, at any time tune in one of those negative pictures, he has one or two alternatives open to him for putting matters right.

A Small Refinement

The main point to keep uppermost in one's mind is the assurance that the receiving set is capable of delivering the power required with the minimum of distortion.

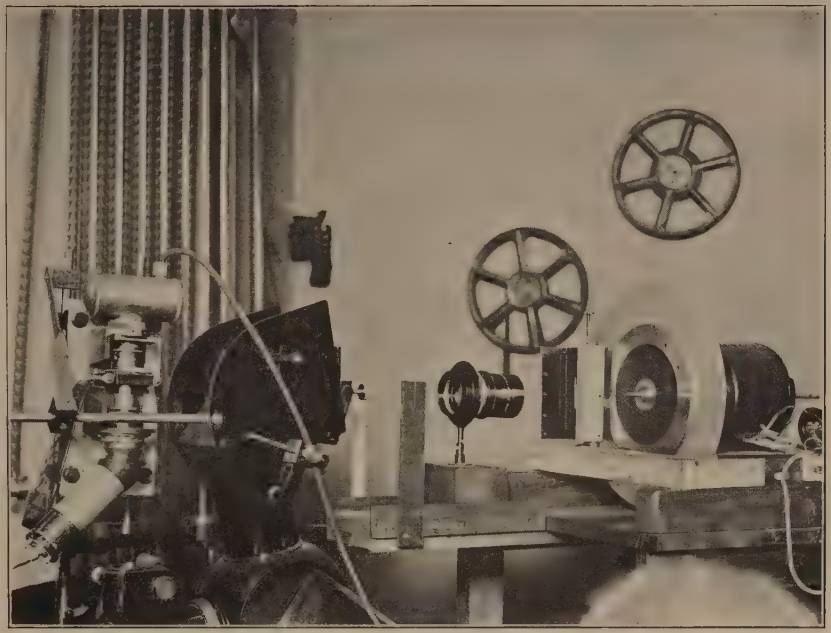
With these two criteria provided for, all is plain sailing.

Some may prefer to include a form of change-over switch in the output circuit, so that the television transmission may be tuned in as an audible note initially, after which the neon can be brought into circuit.

This is quite simple.

Remember, nevertheless, that generally it will be necessary to have an increased negative bias on the output valve, or valves, when the loud speaker is functioning than is the case when the neon itself is circuit.

This can be provided for in the operation of the change-over switch.



The Experimental Apparatus Used when the First Public Tele-talkie Demonstrations were Given in the Baird Laboratories

CHAPTER VIII

TELE-CINEMA AND TELE-TALKIES

An extraordinary situation in the fascinating history of television was the development of what is now called the tele-cinema. One found in Berlin, where the liveliest interest has always been manifested in television, that the Germans paid more heed to this branch of the science than to television proper. In other words, they saw more immediate entertainment value in the presentation of a television film than in the televising of a living image; and there is all the difference in the world between transmitting the one and the other.

The attitude adopted by Mr. Baird was that he had gone beyond the stage of televising films and that, in fact, the tele-cinema was, from the scientific standpoint, a retrograde step. The attitude of the Germans was consistent on this point, inasmuch as they declared that before television proper could be perfectly achieved it was better first of all to perfect a film image, using this stage as a stepping stone to higher things.

First Steps in the Evolution

The transmission of visual transparencies formed originally the first step towards television, and tele-cinematography, which involves only the transmitting of moving transparencies, is a very much simpler proposition, and was one of the first steps leading up to television.

The reason it is much easier to transmit a transparency is that the light in this case passes through the object to be transmitted, and there is, therefore, a very large amount of light available. Thus, the problem of

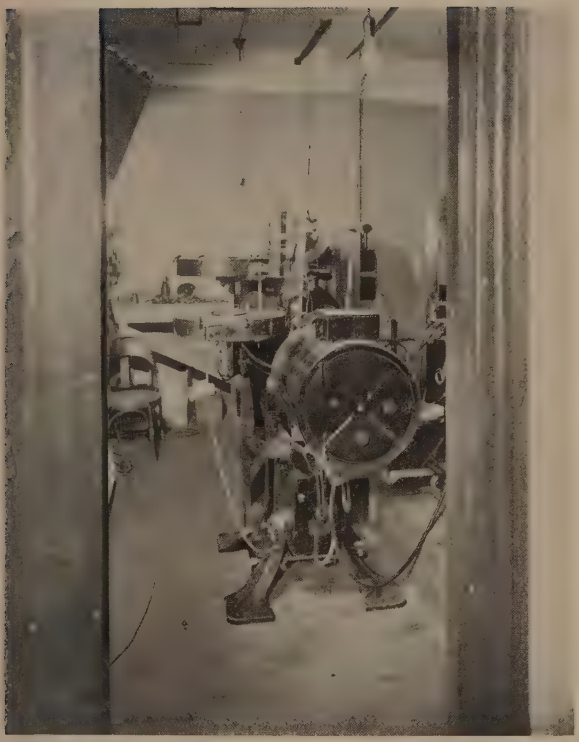
securing sufficient light to activate a photo-electric cell does not exist, although it was this problem which, in the early days of television, formed one of the chief barriers to its success.

The broadcast of films, unaccompanied by sound, proved in practice to have very little entertainment value, and the transmission of silent films does not appear to have any immediate promise of proving a competitor to television proper. The transmission of films accompanied by sound is, however, a very different proposition, and efforts have recently been made, therefore, to transmit talking films by television.

The Talking Film Explained

The modern form of talking films consists of an ordinary film, having printed along one side a ladder-like band of light and shade, representing the sound. This ladder-like band, as the film is projected, passes in front of a narrow ray of light, which is transmitted through the varying densities, and falls upon a photo-electric cell, setting up in the photo-electric cell an undulating electric current, which, after amplification, operates a loud speaker, and reproduces the sound accompanying the visual projection of the film.

In adapting this to television the visual effects are transmitted in the ordinary television manner—that is to say, by scanning the image at the transmitting end with the aid of a disc perforated with a spiral series of holes, and at the receiving station using a similar disc, in conjunction with a neon lamp, to reconstruct the image. The sound effects are simply picked up from the marginal record on the film in the usual way by means of a photo-electric cell, as used in standard talking picture practice, and these sounds are transmitted simultaneously with the film, either by wire or wireless.



A Tele-talkie Machine in the Control Room of the Baird Television Corporation of America

Using Normal Television Receiving Apparatus

Since tele-talkies are sent out in a manner very similar to the transmission of television, they can be received on the identical machine which receives television images. The standard films are used, but naturally subjects must be chosen which are suitable for transmission by television—say, for example, head and shoulder representations. As in television, larger scenes, such as boxing matches and plays, can be sent, but these transmissions are lacking in detail. The frequency band at present available for television is 9 kilocycles, as has been mentioned earlier, and this sets a limit to the amount of small detail which can be transmitted, but as the art progresses there can be no doubt that larger wave bands will be set aside, and images of larger scope will be broadcast.

Television programmes first sent out will consist chiefly of television proper, which is, of course, the most interesting—that is to say, the transmission of actual persons as they sit in front of the microphone, so that the audience can see on the screen of their " televisors," and hear the person who is broadcasting from the studio, but as at present in sound broadcasting gramophone records are occasionally played, so also will television programmes be supplemented by the occasional transmission of tele-talkies.

An Ingenious Cinematograph Projector

The apparatus used for the transmission of talking films is shown in one or two of the illustrations. The cinematograph projector is one of the type which was popular some twenty years ago, and has no Maltese cross or shadow, the film moving continuously with the picture being changed by means of an ingenious arrangement of rotating and cam-operated mirrors. This has

the advantage that the television scanning disc, upon which the image of the film is projected, continuously explores an uninterrupted moving picture. The arrangement of the transmitter and receiver for tele-cinematography is identical to that of television by flood lighting, with the exception that the image projected upon the

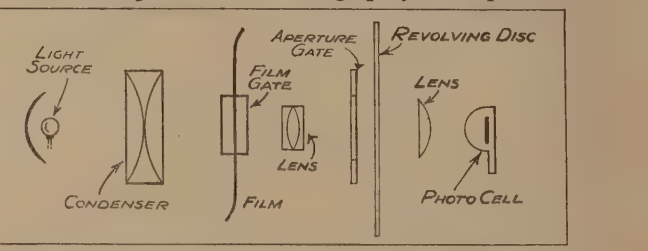


FIG. 25. A SCHEMATIC REPRESENTATION OF HOW CINEMA FILMS ARE TELEVISED

transmitting disc comes from a film and not from a real scene.

Let us examine this a little more closely, for undoubtedly the scheme is a particularly interesting one, and it is to Mr. Baird that the credit must be accorded for successfully combining tele-cinematography together with speech reproduction (or tele-talkies, as it has been popularly called) for use with television apparatus. During some of his very earliest experiments he proved to his own satisfaction that his television methods, then just emerging from the chrysalis stage into a more concrete form, could be applied successfully to film reproduction. This was laid aside, however, so that full time could be devoted to the more acute problems of real television.

Describing the Transmission Process

In addition to the cinematograph projector itself, there will be required a condensing and projection lens,

THE FIRST TELE-TALKIE TO BE PUBLICLY DEMONSTRATED
(THE INIMITABLE GEORGE ROBEY AS A BRIDE)
Note how the Sound Record Runs Down a Side-track in the Film

a "gate" for controlling spot light depth, the usual rotating disc with a spiral of square perforations, and finally the photo-electric cell with its amplifier. Note that since there is ample light actually passing through the film and finally reaching the cell as direct light, and

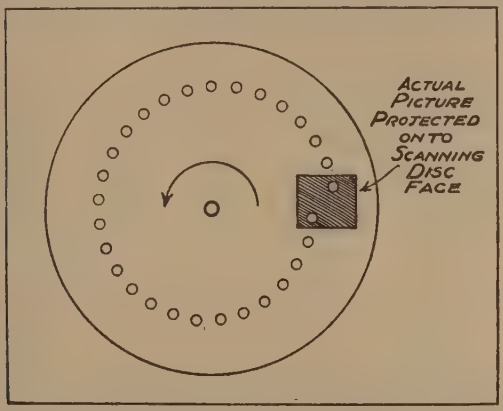


FIG. 26. SHOWING HOW THE PICTURE IS PROJECTED ON TO THE ROTATING DISC AND SCANNED BY THE SPIRAL OF HOLES

not reflected light, only one cell is required and not three or four as in television proper.

Fig. 25 gives a rough diagrammatic representation of the scheme adopted, although, of course, no mechanism is portrayed. After the rays of light have passed through the condenser they meet the film passing through its own gate or guide, and, with the aid of the lens shown, an actual image of the film is projected on to the scanning disc.

By turning to Fig. 26 you will see exactly what is meant, the shaded rectangle being the projected picture, and by revolving the disc it is possible to scan the projected picture. At any one instant that a hole is passing over the picture it will allow a certain light

value to pass through according to the elemental area scanned, and this is made to influence the photo-electric cell, another lens being called into operation here to ensure that the light passing through the disc is " spread " over the active area of the cell.

The Operator has Complete Control

As in the case of ordinary television, this process takes place at a high speed, and spot by spot and strip by strip the cinema image is dissected and converted into its current pulses, and these, after being passed through the usual amplifier, are sent out either over a line or broadcast into space as desired.

The object of the aperture gate is to ensure that actually there is a very short yet definite period when no spot is traversing the picture, and thus produce the " dark strip," which as we saw in Chapter V is essential for synchronizing. In addition, the lens between the film gate and aperture gate is made adjustable in an horizontal direction. Then, by careful manipulation, it is possible actually to pick out a portion of the film picture, say an artist's face, and enlarge this to give a close-up which may be scanned in the normal manner. This is a very useful part of the whole scheme, and gives the operator complete control over his apparatus.

As was mentioned earlier, the particular cinema projector which lends itself best to television working is that in which the film passes through as one continuous, smooth motion, and has no shutter, the actual picture change being effected through the medium of cam-operated mirrors on a rotating shaft.

Suiting Any Type of Projector

Of course, if the other type of projector is employed, that is, one in which the film is moved before the light

in rapid jerks, with the transition period from one picture to the next being masked off by having a synchronized shutter cutting off the light, then more accurate timing of the actual picture exploration is called for. One complete revolution of the disc must coincide with the complete exposure of each picture, and then the shutter operation can take place during

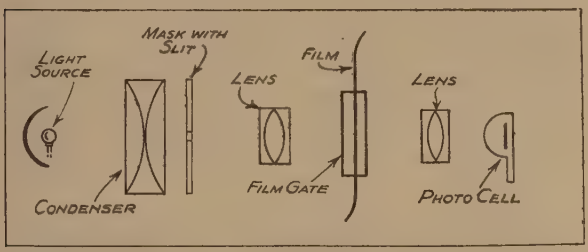


Fig. 27. How the "Sound Effects" on the Film are Handled by the Photo-electric Cell

the brief interval between the end of one spot traversal and the beginning of the next. Obviously, matters would be rather upset if spot scanning was in progress during the shutter period.

We now come to the sound reproducing side of the apparatus, and instead of using a scanning disc we must arrange to reconvert the sound record running down the side of the film into intelligible speech and music. A very good impression of what this sound record looks like in actual practice can be gathered from an examination of the photograph depicting the tele-talkie film of George Robey as the bride in a wedding scene. The varying density of the short horizontal lines is the "sound effect," and naturally the size of the picture has to be reduced slightly to accommodate this on the standard size film.

Producing the Sound Effects

A narrow slit of light passes through a specially cut mask (see Fig. 27) from the light source and condenser. A lens focuses and projects this light strip on to the narrow edge of the film passing through the gate shown.

According to the overall density of the sound track, so a proportionate and continuously varying amount of light passes through, and by means of another lens is dispersed over the active area (the cathode) of the photo-electric cell as indicated. As in the case of the televised image, the light pulses are converted into current pulses, and, after amplification, pass to the line or wireless transmitting station.

Naturally, there must be synchronism between the voice or music and the actual symbolic movements of the film, and this is provided for on the actual projector itself.

Synchronizing Voice and Subject Movement

The sounds relating to any one particular picture have to be printed on a different portion of the film, either ahead or behind that picture, according as to whether the talkie apparatus reproduces after or before the picture. There is, therefore, a "floating" loop of film between the two positions for the respective cell activations, and this has to be adjusted to give the voice and subject movement synchronism required. Once set on any film it will run through satisfactorily.

Another point to note is that in those projectors possessing the shutter or jerky motion for the pictures, when it comes to reproducing the sound, the film motion must be smooth and continuous, and special provision has to be made for this in the apparatus mechanism itself.

The First Public Demonstration

Tele-talkies were first publicly demonstrated in the Baird laboratories at Long Acre on 19th August, 1929, and since then have been the subject of much speculation in the press as to their future. Of course, they will have their special aspect in the apportionment of television programmes, but it would seem that their best use is in the form of " dovetails " in much the same way as gramophone recitals are now in aural broadcasting. In any case, they form a media for expressing certain events which cannot conveniently be done with ordinary television, and for this alone they will be welcomed, and add to the variety of fare which the home " televisor " is capable of providing once the television transmissions become a regular feature of reasonable length. Until then, television proper undoubtedly holds the field.

CHAPTER IX

NOCTOVISION AND THE "NOCTOVISOR" RECEIVER

LET us consider noctovision. While other competitors have arisen in the field of television, Mr. Baird has still a complete monopoly as far as noctovision is concerned.

Even at the time of writing there appears to be no opposition to Mr. Baird's title as the originator of a science that bids fair to conquer darkness and fog.

Although, strictly speaking, noctovision forms a different invention to television, and one with a very different application, it is so similar in operation to the processes we have described, and is of such scientific interest, that its inclusion in these pages follows as a matter of course.

Overcoming Personal Discomfort

In his first experiments with television, Mr. Baird found the greatest difficulty in reducing the intensity of the light used to illuminate his subjects without impairing the efficiency of the apparatus as a whole. The persons who sat before the scanning disc suffered considerable discomfort, and, in endeavouring to find a way out of the trouble, the idea occurred to him to use invisible rays instead of visible light.

As readers are no doubt aware, visible light and the various invisible rays are in principle just like wireless waves, that is to say, they are vibrations in the ether. The visible spectrum contains colours ranging from violet at the high frequency end, passing to red at the low frequency end, the entire range of colours passed through being violet, indigo, blue, green, yellow, orange, and red.

THE 1927 "NOCTOVISOR," SHOWING THE ARRANGEMENT OF THE EBONITE FILTERS

The invisible *ultra* violet rays were first tried; then, finding that these were not only most objectionable to the sitter, but also suffered from the defect that the lenses filtered out quite a large proportion of the active rays, attention was turned to the other end of the spectrum, that is, the *infra* red.

Improvements Effected with Infra Red Rays

The *infra* red rays have very great penetrating powers and no bad effect on the sitter, but they have also a very small photo-electric response, and in the early days it was quite difficult to obtain satisfactory results with these rays. Efforts were, therefore, made towards increasing the efficiency of the optical side of the apparatus and also the sensitivity of the photo-electric cells, and, once this had been accomplished, it was possible to use the rays so that images could be seen with the object in total darkness!

Obtaining an Infra Red Image

Now how is this accomplished? Most sources of illumination generate these *infra* red rays, and to separate them from the luminous portion it is necessary to place an absorption filter in the path of the light, so designed that it will only pass these rays. One of the simplest and perhaps best known of these filters is thin sheet ebonite, so for the original noctovision tests Mr. Baird shielded all his "flood lights" with ebonite, so that the person being televised was seated in total darkness.

As indicated in Fig. 28, the *infra* red rays play on the person, with the result that an "*infra* red image" was focused by lenses on to the scanning disc with its spiral of holes. The photo-electric cells were thus influenced by each elemental area of focused image that passed

through the perforations, and the resultant variations of current were amplified, transmitted by wire or wireless to the place of reception, and received on a normal "televisor" in the usual manner.

Amongst the cells which are more sensitive to the *infra* red end of the spectrum we may mention hydrogen, caesium, thallofide, and rubidium, and really the

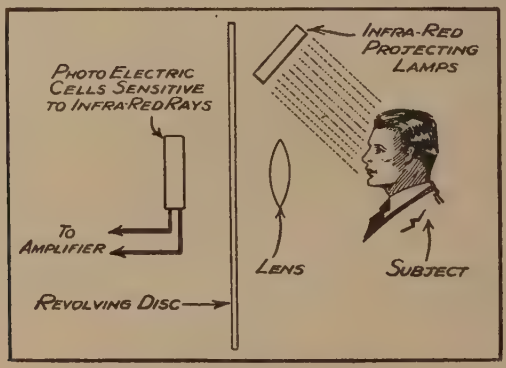


Fig. 28 Showing how the Infra Red Rays Play on the Person being Televised

results of these early demonstrations created a stir in the scientific world.

For normal television purposes there was really no advantage to be gained by using *infra* red rays; in fact, they bring in their train certain disadvantages.

Shortcomings of the Earlier Photo Cells

First of all it was somewhat difficult to use the rays, and secondly, it is generally inconvenient for the subject to sit in total darkness. Furthermore, *infra* red rays with the older type of photo-electric cells did not give the correct colour values, red appearing as white, while blue does not appear at all. The effect, therefore, was

The Latest Type of "Noctovisor" Shown in Operation with Mr. Baird Manipulating the Controls

to give a rather ghostly appearance to the image of the person being transmitted. Hence, although when noctovision was demonstrated at the British Association in Leeds in 1927 it proved such a popular scientific exhibit that the police had to be called in to regulate the queues, it really represented no advance for normal television purposes until the newer types of cells were developed. With these, excellent results are now being obtained, and noctovision is being " reborn."

Noctovision, however, has other potentialities quite apart from television, as, say, for example, the development of a means of vision which would enable attacking forces in wartime to be seen without their being aware of it.

Fog Penetrative Powers

Better still, the scope of its application has extended to a more useful commercial possibility which depends upon the fact that *infra* red rays penetrate fog. Actually, fog or mist is penetrated by light, or by ether waves, proportionately to the fourth power of the wavelength. That is to say, short waves of the *ultra* violet order are dispersed very quickly, while longer waves such as the *infra* red have great penetrative power.

The old observation that the sun turns red when it sets is simply an indication of this phenomenon, for the light from this source is passing through a great deal of fog, mist, and atmosphere, and all the visible light except the red is filtered out. The *infra* red rays possess that property proportionately, and they penetrate fog better than the red rays, just as the red rays penetrate fog better than the blue rays.

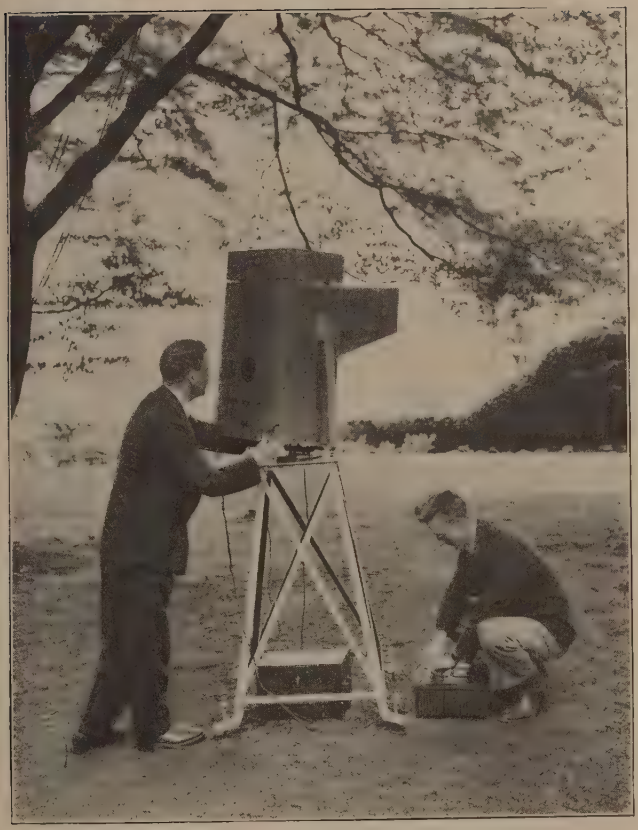
This has led to the development of the " noctovisor " receiver, which was first publicly demonstrated on 9th August, 1929, and as can be gathered from the photographs bears little resemblance to its prototype of 1927.

In effect the " noctovisor " receiver is an eye which sees by the invisible *infra* red rays, so that it can be used not only in the dark, but will see through fog that would be completely opaque to the unaided human vision. Fog is the mariner's worst enemy, and the one remaining obstacle to safe shipping. Directional wireless has given us a palliative to this, but not a cure —for directional wireless can only indicate a course, but cannot give anything approaching direct vision. The " noctovisor " receiver provides this, and on the date mentioned was witnessed what may well prove an epoch-making advance in navigation, both by air and by sea.

A Unique Demonstration of the Latest " Noctovisor "

On the top of Box Hill was erected a special instrument, consisting essentially of a television transmitter and receiver mechanically coupled together, and adapted to work upon *infra* red rays. This camera-like device was mounted upon universal pivots and provided with graduated scales, so that it could be pointed at any part of the horizon, and by means of the graduated scales the bearing of the exact spot at which it is pointed can be read off. On a little screen at the back of the " noctovisor " can be seen an image of any light which comes within its range, and this although the light is obscured by fog, or by any substance which cuts off all the visible light, provided that the substance allows the *infra* red rays to pass through.

As was mentioned earlier, one of the commonest substances of this kind is ordinary sheet ebonite, which acts in effect like an enormously dense fog, and this was the artificial fog used at the demonstration given at Box Hill, when from the Swiss Cottage, a chalet-like



A Graduated Scale at the Base of the Instrument Gives the Exact Bearing of a Light in Relation to it

dwelling house on the highest point of Box Hill, the light of a car was clearly shown on the screen of the "noctovisor," and the bearing of the car ascertained, although the light was totally invisible to the unaided eye, being obscured by the sheet of ebonite. The test was equivalent to a test made on board ship, and formed a very convincing demonstration of the potential value of the remarkable device.

Among those who have witnessed demonstrations have been some of the leading navigators of the mercantile marine and the Navy, and they have been enthusiastic in their appreciation of its value.

Overcoming the Mariner's Worst Enemy

Picture the operation at sea, when the mariner sweeps the horizon with his "noctovisor" receiver and watches the while the little screen. Should the instrument in the course of its transit pass across the lights of a ship, these lights would appear upon the screen, although obscured to the eye of the mariner by the densest fog, for fog is transparent to the *infra* red rays. What does this mean? It means that fog, the greatest menace to navigation, has been overcome.

In aviation, the device may also be used with equal effect. A smaller form of "noctovisor" receiver could be made for aeroplanes, and would enable the aviator to pick out the lights of the aerodrome, obscured by fog, and invisible to the unaided eye.

Again, the watchers on land can locate an aeroplane hidden by a cloud bank, by means of *infra* red rays, and the uses in warfare, whether by land, air, or sea, must be very obvious. Here the "noctovisor" would be a potent weapon not only because of its fog-penetrating power, but also by its power of seeing in darkness, for consider a hostile force equipped with such

a weapon, they would be able to see without being seen, nor would they communicate their presence as a searchlight communicates its presence by means of beams of light, for the "noctovisor" receiver can operate by searchlights using invisible *infra* red rays, which would not betray their presence to the enemy.

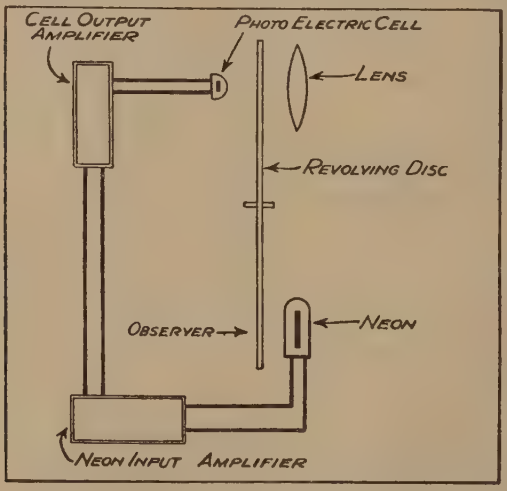


FIG. 29. DETAILS OF THE LATEST FORM OF BAIRD "NOCTOVISOR"

A More Detailed Explanation

Realizing the potency of this apparatus, let us examine its details a little more closely, for they should now be made doubly interesting after studying its possible uses. Actually, the scheme is shown simply in Fig. 29, a lens concentrating an image of the light sought on to a rotating and perforated disc. Behind this disc we have the photo-electric cell specially sensitive to the *infra* red rays, and after passing through two independent amplifiers the converted light pulses of the

cell are fed to the neon. Both cell and neon are diametrically opposite each other and work through the same disc, the neon plate being observed from the back of the instrument, as seen in an accompanying illustration.

With the " noctovisor " receiver we are not seeking a finely detailed picture of the obscured light, but merely wish to have evidence of its presence and to be able to

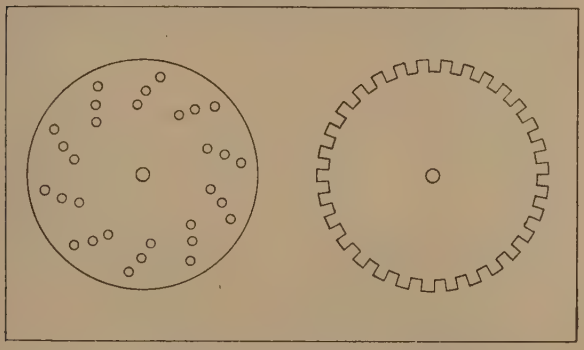


FIG. 30. TWO FORMS OF DISCS USED FOR BREAKING UP THE CONTINUOUS RAYS INTO PULSES

take its bearing. The perforations in the disc can, therefore, be larger than those employed in the normal disc of the spot-light system, for we are anxious to allow as much *infra* red rays to reach the cell as possible, and thereby increase the range of the apparatus.

Special Discs

Since the original demonstration several types of discs have been tried, two forms being indicated in Fig. 30. One is made up of ten sets of triple holes spaced somewhat as shown, while the other is a " chopper " disc to break up the continuous rays into pulses. Actually, a modified form of the chopper disc has given the best results so far, but it would be premature to give actual

details until thorough comparative tests have been completed.

The disc diameter is governed largely by the overall size of the complete apparatus, while it must be possible to mount the neon sufficiently far from the cell to prevent any direct action one with the other. Both amplifiers are efficiently screened, and are housed inside the

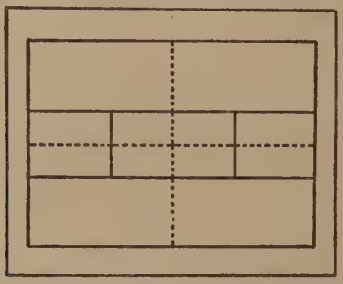


Fig. 31. The Arrangement of the Viewing Screen whereby the Bearings of the Light can be Ascertained

movable body while disc speed and type of disc perforation set a frequency limit to which these valve amplifiers must satisfactorily function.

The neon tube is coupled so that it glows only when a signal is recorded, and when once the presence of a light has been detected, by using the "noctovisor" receiver something in the manner of a telescope sweeping the horizon, the apparatus is manipulated until the light appears as a spot in the centre of a viewing screen (see Fig. 31). As the whole unit is mounted and swivels on a calibrated base, the true bearings can be logged.

Every Avenue Must be Explored

Since it is desired to use the "noctovisor" receiver in times of fog occurring in daylight, special precautions

This Photograph of Arthur Prince and his Famous Ventriloquial Doll Being Televised Gives an Idea of the Intense Lighting Required in the Early Days for "Flood Light" Television

have to be adopted to neutralize or cut out the " daylight signal," and while actual details of this cannot be divulged at the time of writing, the method adopted is most ingenious. The apparatus then becomes sensitive to points of light whose intrinsic brilliance is greater than their background of daylight, and obviously ships' masthead lights fall within this category.

With Britain as a pioneer maritime country we can hope that every avenue of use for the " noctovisor " receiver on board ship will be explored with painstaking care. We cannot afford to neglect anything which furthers the interest of " those who go down to the sea in ships," and while not suggesting that it should supplant any apparatus at present installed for their safety, we can at least anticipate that it will augment that already in use.

CHAPTER X

DAYLIGHT TELEVISION AND PHONOVISION

It will be noted that throughout this book, except, of course, for Chapter I, we have eschewed descriptions of apparatus which in comparison with that now in use can only be regarded as obsolete, but a description of daylight television demands somewhat more than a passing reference to one of the earlier forms of television, namely, flood light television.

In our spot light system we had a powerful light behind a rotating disc, so that the subject's face was illuminated by a succession of light strips, and, in consequence, anyone sitting before the scanning disc suffered no discomfort, since the light only momentarily flashes before the eyes of the person.

Reversing the Process

In the original flood light television, however, the system is reversed, and the scene or object to be televised was flooded with a brilliant light. The intensity of the illumination was governed largely by the sensitivity of the light sensitive device employed to transform the light impulses into electrical impulses, and in those early days these cells were very inefficient.

Obviously, the person being televised suffered rather badly from this brilliant lighting, and one of the accompanying photographs conveys a vivid impression of the number of lamps used by Mr. Baird when conducting his experiments. It must be borne in mind that the light ultimately reaching the photo-cell is reflected light, and this, coupled with the cell's inefficiency, made flood lighting a case of " force puts no choice."

A Phonovision Record Made by the Baird Television Co.

The Same Final Result

Having illuminated our object or scene, therefore, this was scanned by actually projecting it by means of a lens on to the scanning disc. This latter scheme resembles very much the tele-cinema arrangement, and as the disc revolves the succession of small apertures, arranged in a spiral identical with those used in spot light transmission, emits light from every part of the picture in turn on to the photo-electric cell, and thus causes the cell to send out an undulating current proportional to the light and shade of the picture. This undulating current is identical to that obtained by the spot light method, and is transmitted and received in the same way and upon the same apparatus as that used in the spot light methods.

With a period intervening when no improvement took place in photo-electric cells, the flood lighting was replaced by the spot light method, and there matters remained for a time.

Now it is obvious that in order to bring the utility of television to its highest point it is necessary to be able to transmit scenes in broad daylight. This, of course, could not be done with the spot light process, but all that was necessary was a modification of the flood light system, for daylight is rich in rays which affect the newer types of photo-electric cell.

A Milestone of Progress

The achievement of daylight television nevertheless marked a milestone in the progress of the art, and it was first accomplished in July, 1928, when Mr. Baird demonstrated the transmission of scenes illuminated only by daylight before Sir John Ambrose Fleming, other scientists, members of the press, and interested spectators. Brilliant sunshine is not necessary, for the apparatus

functions satisfactorily on an ordinary day, and the scene of the first successful experiments was on the roof of the Baird Co.'s laboratories at Long Acre.

It will be obvious that as daylight has proved amply sufficient to give television, there is no barrier *as far as lighting is concerned* in the transmission of extended scenes, such as the finish of the Derby or the Boat Race, but the amount of detail which can be transmitted over the 9-kilocycle waveband at present available would be inadequate to represent properly such scenes.

As television advances, however, we may anticipate that larger wavebands will be granted, and these scenes should then come within the scope of the television broadcasts.

To use the words of Sir John Ambrose Fleming, we can anticipate the day when this type of transmitter becomes in effect a more complicated form of outdoor camera, in which the screen on which the image or scene appears is not immediately behind the lens, but may be miles or hundreds of miles away.

"Bottling-up" Pictures

A development of fascinating importance occurred at this juncture—that was the means of concentrating or bottling up pictures—in a word, the discovery of phonovision.

At the time of writing, Britain again leads in regard to this science, inasmuch as Mr. Baird is the only inventor who has applied his knowledge of television to this most popular form of entertainment. What is phonovision?

In television the person or scene being transmitted is first of all transformed into an undulating electrical current, which is sent through the ether or along wire. Now this current can be heard just in the same way as the current giving rise to the sounds we hear on a

THE TRANSMITTING END OF THE PHONOVISION PROCESS RECORDING A DUMMY'S HEAD ON AN ORDINARY RECORD

telephone, so that anyone connecting a telephone in place of a "Televisor" hears, instead of sees, scenes which are coming through. A face, for example, is heard as a peculiar rhythmical humming, every face or scene having its own descriptive note.

Synchronizing Unnecessary

Now, if these notes are played into a recording gramophone they are recorded just as the ordinary

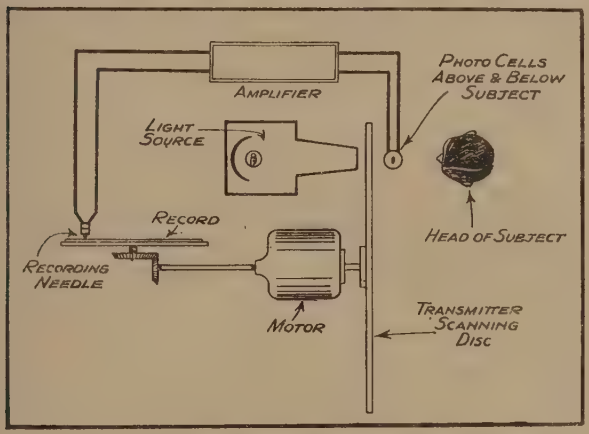


FIG. 32. HOW PHONOVISION RECORDING TAKES PLACE

sound is recorded, and if the record is then played with an electrical pick-up the undulations on the record are turned back into electrical impulses similar to those which originally produced the undulations, and if in place of being connected to a loud speaker it is connected to a "Televisor," the original scene is reproduced. It is unnecessary to synchronize, as the scanning disc and vision record are driven from the same motor, so that the apparatus is quite simple in operation.

The schematic arrangement of the recording side is

indicated in Fig. 32. Both scanning disc and record are driven from the same motor, and with the usual spot light arrangement the singer's face is broken up into light strips, the light pulses are handled by the photo-electric cells and the resulting signal current, after amplification, passed to the recording needle, which makes indentations in the record.

Reproducing from a Record

If desired, a synchronized record can also be made of the voice and music, or, alternatively, a double track

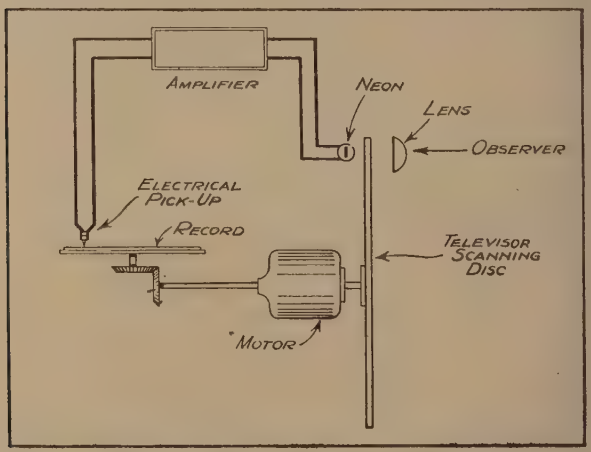


FIG. 33. THE SIMPLE SCHEME ADOPTED TO REPRODUCE THE IMAGE PREVIOUSLY MADE ON THE RECORD

made on one record, one track taking the television signal and the other the aural signal.

When it is desired to reproduce this the simple scheme of Fig. 33 is employed. The electrical pick-up takes the signals from the record and these are then amplified and fed to the neon, the motor driving the record turn-table also driving the disc through suitable cog wheels

A Stage in the Phonovision Process Showing some of the Early Experimental Apparatus]

to ensure picture synchronism. The means adopted for reproducing the voice will depend on whether a separate synchronized record is made, or whether a double track record is in use.

The appearance of a phonovision record can be gathered from one of the accompanying illustrations, and it really is quite weird to listen to face movements or notice the changing of the note produced by smoothing, say, the chin by the hand or brushing back the hair.

What of the Future ?

We have, therefore, an alternative device to the cinematograph, which gives us the means of recording faces or scenes upon gramophone records. Actually this device represents a very remarkable scientific achievement—we have light turned into sound, sound turned into mechanical indentations, the mechanical indentations turned back into sound, sound turned into electrical impulses, and the electrical impulses into the visual reproduction of the original image.

Now what the future holds for this device it is somewhat difficult to say. Had the cinematograph never been invented it would undoubtedly have been an invention of outstanding and immediate utility. As it is at present it is merely a scientific curiosity, but it has the advantage over the cinema in that it gives a much more convenient method of recording vision, for we can put vision upon a gramophone record and by putting the sound on the same record we have a remarkably convenient form of speaking " film " for the home.

In any case the Baird Co. are pursuing their investigations with phonovision, so that the apparatus may be perfected, and we can anticipate many uses to which this " bottling " of faces may ultimately be put.

CHAPTER XI

COLOUR AND STEREOSCOPIC TELEVISION

HAVING established the principles of television in general, and seen how it has been applied to seeing both in broad daylight and through fog, together with the "bottling" of images, there are still two more ramifications explored by Mr. Baird which are of equal importance. This is in colour and stereoscopic television, the former being first demonstrated in July, 1928, and the latter in the following month, both these advances being shown at the meeting of the British Association in Glasgow of the same year.

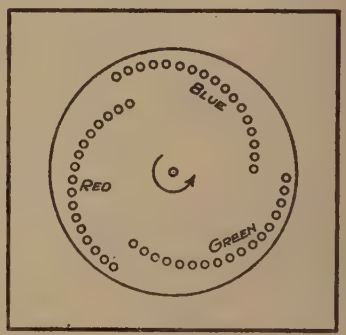


FIG. 34. A TRIPLE SPIRAL DISC COVERED WITH RED, BLUE, AND GREEN FILTERS IS REQUIRED FOR COLOUR TELEVISION

Special Light Filters Required

Taking advantage of the fact that red, green, and blue are the three primary colours from which every visual colour can be built up by combinations, Mr. Baird made up a triple spiral disc, each set of perforations being covered with red, green, and blue light filters (see Fig. 34). Using this disc on the spot light system, it was thus possible to transmit, via the photo-electric cells, current pulses corresponding respectively to the red, green, and blue parts of the scene or subject televised. Naturally, a geometrically similar disc, covered with

The Commutator Necessary for Changing Over to Each Light Source in Turn is Clearly Seen in this Photograph

the same colour filters, was employed at the receiving end, but it was essential to have a light source rich in red, green, and blue rays.

First of all a special glow discharge lamp containing a mixture of neon, helium, and mercury vapour was tried, but little success attended these efforts, so it was decided to have two separate light sources.

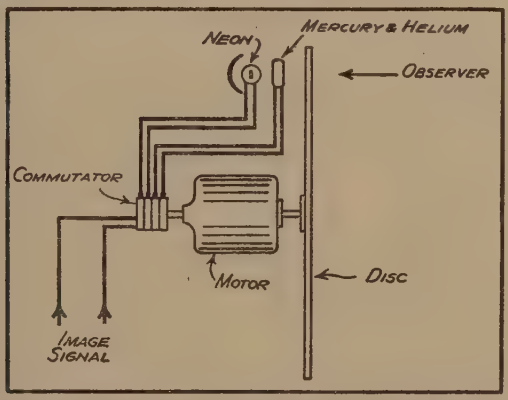


FIG. 35. A COMMUTATOR IS EMPLOYED TO CHANGE OVER FROM THE NEON LAMP TO THE MERCURY AND HELIUM LAMPS

Two Light Sources in Use

Now the neon lamp itself is rich in the red rays, so an additional lamp, containing mercury and helium vapour, was constructed, the mercury vapour supplying the green light and also part of the blue, while the presence of the helium assisted in producing the blue light. Of course, the inclusion of two lamps at the receiver end complicated matters slightly, but this was overcome quite easily by using a commutator on the driving motor shaft, so that only the neon lamp was illuminated when the red filter holes were revolving in front of the observer, the mercury and helium lamp

taking its place as soon as the blue and green filter holes came into position.

A rough idea of the arrangement can be gathered from Fig. 35, the transmitter arrangements being identical with that for the ordinary spot light method, except for the special disc, while an examination of an accompanying photograph shows Mr. Baird with one of his hands close to the commutator and brush mechanism.

Vivid Portrayal of Colours

To give the same number of complete pictures per second, whether red, green, or blue, the speed of the transmitter disc should be increased three times, but in actual practice this was found unnecessary, owing to parts being common in the three coloured images.

Of course, it will be observed that the three individual signal images all pass along the same photo-electric channel, and thus only one wave-length is required for transmission purposes. This is important, and will correct the impression that has got abroad that three separate communication channels are necessary.

Using colour television, it is possible to portray fruit, flowers, and coloured clothing very vividly, and obviously developments in this particular sphere will have very far-reaching effects once all the details have been perfected. Imagine the appeal to the ladies with a fashion display, say, in Paris, with arrangements made for televising the mannequins with the natural colours of the gowns appearing on the screen! A peep into the future, perhaps, but a pleasure to look forward to.

What is Stereoscopic Relief?

Not content with the success which crowned his colour television demonstration, Mr. Baird immediately turned his attention to television in stereoscopic relief.

This Photograph was taken during the Baird Co.'s First Official Demonstrations of Television Transmission and Reception in Berlin

First of all, what do we mean by stereoscopic relief? Anyone with their eyesight unimpaired has an impression of stereoscopic relief, depth or distance, when they look at an object or scene, and the effect is brought about quite naturally by the combination of the separate images seen by our individual eyes.

Look at an object placed about a yard from the eyes, and rapidly close one eye at a time, and you will have the impression of the object moving slightly from right to left and left to right, as each eye shuts in turn. Actually, the right eye sees a slightly different view of the object to that seen by the left eye, and these views are combined in the brain to give the depth, and enables us to judge distances and sizes.

The old stereoscope so familiar to the early Victorian parlour table was designed on this principle, two photographs side by side being viewed through prisms separated by about $2\frac{1}{2}$ in., this being approximately equivalent to the separation of the human eyes, and the result was a true-to-life impression of the scene or objects photographed.

Two Separate Explorations Must be Made

Now, how can we secure this stereoscopic effect with television? Why, by having a disc with a double spiral, so that two separate scans or explorations of the subject are made, one to correspond to the image seen by the right eye and the other corresponding to the image seen by the left eye. The disc, therefore, resembles that indicated in Fig. 36, one spiral being located near the periphery and the other nearer to the centre.

There are two sources of illumination, and two lenses at the transmitting end, one beam of light being focused through one spiral and the second beam through the remaining spiral, the scheme being made

clear by reference to Fig. 37. This double set of light impulses given to the photo-electric cells only needs

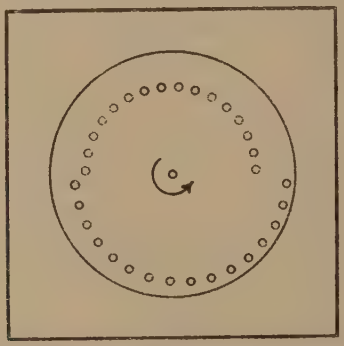


FIG. 36. TWO SEPARATE SPIRALS ON THE SAME DISC ARE NECESSARY FOR STEREOSCOPIC TELEVISION

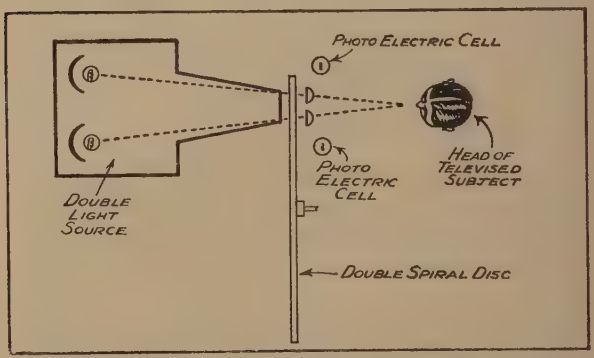
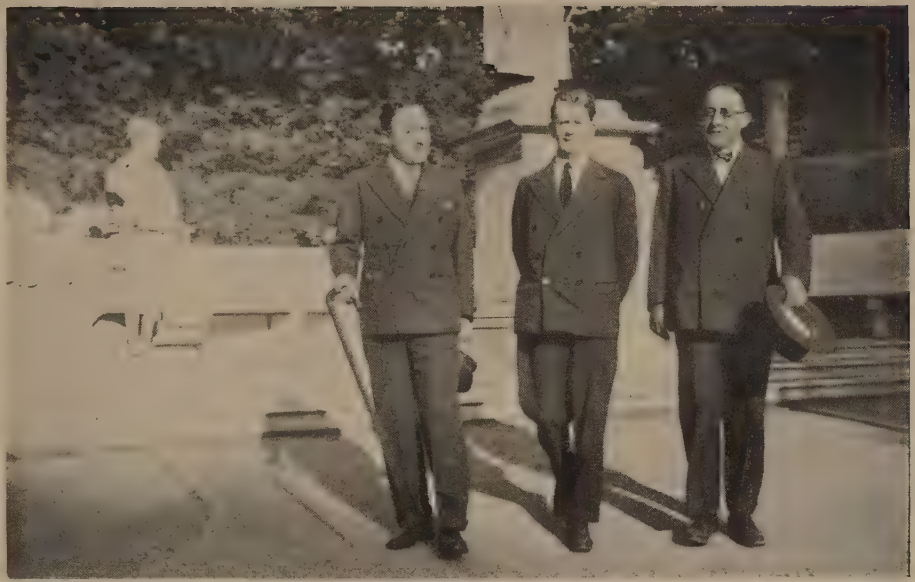


FIG. 37. THE DOUBLE BEAM OF LIGHT AT THE TRANSMITTER FOR STEREOSCOPIC TELEVISION

one channel of communication, and some idea of the first experimental apparatus used in achieving this stereoscopic transmission is shown in one of the accompanying illustrations.



MR. BAIRD, CAPT. HUTCHINSON, AND MR. MOSELEY IN BERLIN WHEN THE GERMAN COMPANY—FERNSEH A.G.—WAS FORMED

Colour Combined with Stereoscopic Relief

At the receiving end we have a double spiral disc proportionately similar to the transmitter disc, and, in consequence, there are two slightly different images appearing on the screen. These are combined by means of an ordinary stereoscope, so that the observer gains his impression of depth and distance with the subject

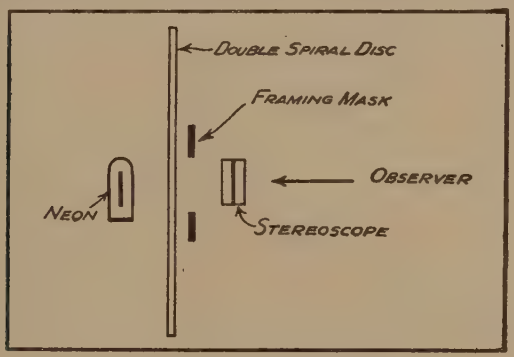


FIG. 38. SKETCH OF THE ARRANGEMENT ADOPTED AT THE RECEIVING END

before the transmitter exploring disc. Fig. 38 portrays the arrangement adopted, the only difference from the normal " televisor " being the addition of the stereoscope to blend the two separate images.

The life-like appearance of the stereoscope image when compared with the " flat " image is most marked, and it must be borne in mind that it is possible to achieve this effect with colours also. The transmitter and receiver discs, then, have two sets of triple spirals, with red, blue, and green filters instead of a single set.

Small wonder that one is inclined to say that television, with its ramifications, borders on the miraculous.

CHAPTER XII

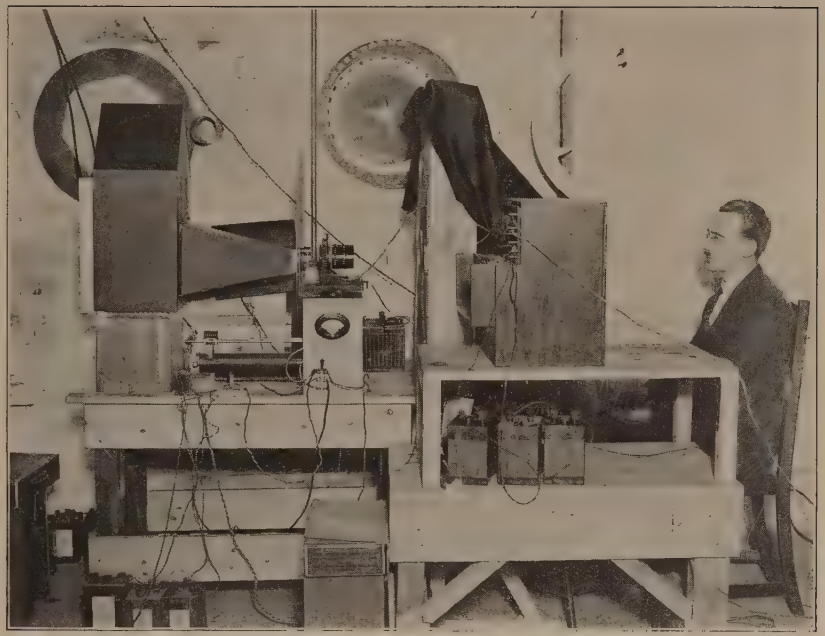
TELEVISION IN OTHER COUNTRIES

We have so far confined ourselves more or less to the achievements of television in Great Britain. As explained in the Introduction to this work, this has been done in order to correct certain views expressed in books emanating from abroad. Besides giving credit where credit is due, that is, to the Scottish inventor who first demonstrated television, we have at the same time included in this work the latest developments in all branches of the science.

At the same time, we are in no mind to ignore the claims of those foreign investigators who have been working in friendly rivalry with Mr. Baird. Indeed, in many ways it has become an international race in the perfection of television. There is no doubt that the success achieved by the British inventor served to stimulate the efforts of his rivals abroad.

Early Pioneer Efforts

Let us see what these other inventors have achieved. The early efforts of television pioneers seemed to be focused on methods for constructing a duplicate of nature's television system—the eye—by substituting selenium for visual purple and building an artificial retina out of a mosaic of selenium cells, each of these cells being connected by wires to a shutter. This shutter opened when light fell on the cell connected with it, and allowed a spot of light to fall on a screen. In this way each cell controlled a spot of light, the image being reproduced by a mosaic formed of these spots. Models



Some of the Original Baird Apparatus Used for Giving Demonstrations in Stereoscopic Relief

on these lines were actually made, prominent amongst them being those constructed by Rignoux, Fournier, and Ernest Rhumer.

A Mirror and Cathode Ray Combination

Jan Van Szopanik suggested vibrating mirrors, as did also Boris Rosniz, but in the case of the latter he introduced an original scheme, dispensing with mechanical parts and using cathode rays instead. Then, again, in France we have two noteworthy workers in Belin and Holwick. Their transmitter consisted of two mirrors vibrating at right angles to one another, thus causing the image to traverse a potassium photo-electric cell. The current from this cell controlled the intensity of the cathode ray at the receiver, the ray being caused to traverse a fluorescent screen by magnets energized from an alternating current transmitted from the motor which moved the mirrors at the transmitter.

It would appear, however, that nothing in the nature of commercial or practical television has so far been achieved in France.

Jenkins' Work in the U.S.A.

In the United States of America television workers have been extremely active, and foremost amongst them we have C. F. Jenkins, whose name is, like that of Monsieur Belin, known in connection with photo-telegraphy. He has contributed to the science a most ingenious device known as the disc prism. This consists of a circular glass disc, the edge of which is ground into a prismatic section, the section varying continuously round the circumference. Light passing through the disc is, therefore, bent backwards and forwards as the section changes, and by passing the image through revolving discs of this nature it is made to traverse a

photo-electric cell. The current from this cell is transmitted to the receiving station, where it controls the light from a lamp invented by Mr. Moore. This lamp changes in intensity instantaneously in proportion to the current, and its varying light is caused to traverse a screen by a similar device to that of the transmitter.

Of late, however, Mr. Jenkins has abandoned his lens prism and is now conducting work on a 48-hole spiral disc.

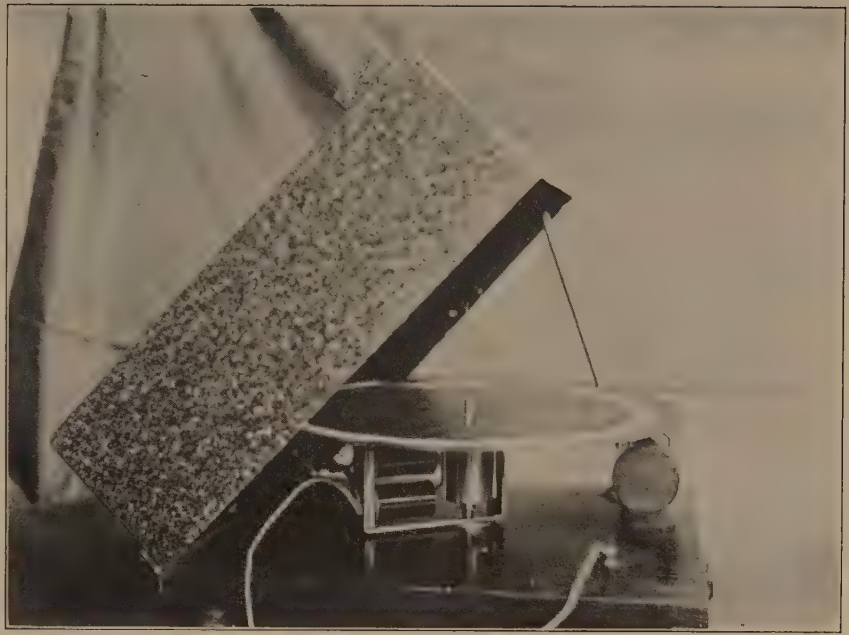
Jenkins' work is meritorious in the highest degree, although it has been rather overshadowed by the spectacular demonstrations of the American Telephone and Telegraph Co., which, in April, 1927, gave a series of television demonstrations, both by land line and by wireless, between Washington and New York, and then showed colour television after Mr. Baird.

Problem of Synchronism Not Solved in America

In recent times America has been the scene of feverish activity in the television field, but little commercial success has attended the various television companies. Their lack of success may be attributed to the fact that the television models which it was attempted to market had no device for synchronism, so that it was impossible to see the images for more than a few seconds at a time, and constant adroit manipulation was required by the operator to keep his receiving machine in anything approaching synchronism with the transmitter. Of course, matters were all right when transmitter and receiver used the same power mains, but as has been mentioned before, this restricts considerably the field of utility.

Mihaly and His "Telehor"

In Germany the most prominent worker has been the Hungarian, Denes von Mihaly, who made prominent



THE MIHALY "TELEHOR" WITH COVER LIFTED TO SHOW HORIZONTAL SCANNING DISC, SMALL MOTOR, AND NEON LAMP

claims as far back as 1923 for a device which he termed the " telehor." This consisted of little mirrors, suspended upon two thin wires, vibrating in front of a powerful electric magnet. The " telehor " appears to have been incapable of achieving demonstrable results. In any case, in 1928 Mihaly abandoned his " telehor," and, following the lead of Baird, adopted the rotating Nipkow disc, neon tube, and synchronous motor.

At the 1929 German Wireless Exhibition, held in Berlin, actual television was not demonstrated by this inventor, but he had two transmitters of his own in operation, one sending a lantern slide, and the other a film. Mihaly has not so far publicly demonstrated any form of automatic synchronizing; he has used the same A.C. mains to drive transmitter and receiver motors.

An Obvious Defect

One theory of his was to short-circuit the photo-electric cell six times per revolution of the transmitter scanning disc, through the medium of a commutator mounted on the end of the transmitter motor shaft. While this drastic treatment cannot be said to improve the photo cell, it is likely to cause a flash-over of the wireless transmitter. The maximum signal must always be controlled by the wireless transmitter; therefore the picture signal would have to be unreasonably reduced to allow for this. The signal at the receiving end has its high frequency component by-passed into the neon circuit while the synchronizing pulses are filtered out, amplified, and finally made to drive a phonic wheel, to which is coupled the receiver disc.

More recently, the well-known Telefunken Co., under the direction of Dr. Karolus, have taken up the problem of television in a serious manner, and, using the mirror drum of Weiller, have achieved some excellent results.

Their apparatus was also demonstrated at the 1929 Radio Exhibition in Berlin, and both tele-cinema and television were shown, the results achieved by them in both cases being of good quality, but the apparatus used made no pretensions at being commercial, and was most elaborate and costly. To secure synchronism, electrically driven tuning forks were used, the forks being exactly similar at both receiver and transmitter. Reliance was placed on these operating identically, but their inherent delicacy makes them victims of even slight temperature changes, and this is sufficient to upset synchronism completely. Furthermore, although tuning forks were used, both the transmitter and receiver machines were driven from A.C. mains.

Work of the Fernseh A.G.

The German Post Office, who, by the way, have adopted the 30-hole disc as standard, devote a good deal of time to research into the various systems of television, but naturally their efforts in this direction, while extremely praiseworthy from the point of view of results, are self-centred as a Government department. Their broadmindedness on television in general is a matter for congratulation, for witness the long series of daily test transmissions from the Witzleben station, which were conducted by the engineers of the Baird Co., using their own system.

Then, of course, we have the Fernseh A.G., a company formed in Germany in 1929, with the Baird International Television Co., Zeiss Ikon, Bosch & Loewe Radio as partners. This company is developing the Baird system in Germany and has made rapid progress, commercial televisors being already in course of manufacture to receive the daily transmissions of tele-cinema from the Witzleben station.

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